# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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| In re Application of: Haase, Richard A. | § | Serial No.: 10/790,316 |
| | § | A continuation of PCT/US 03/11250 and PCT/US 03/41719 |
| Filed: March 1, 2004 | § | |
| | § | Claiming Priority of: PCT/US 03/11250 filed 4/10/03, PCT/US 03/41719 filed 10/11/03, 60/447,880 filed 2/14/03, 60/404,644 filed 8/19/02, 60/379,587 filed 5/10/02, and 60/371,768 filed 4/11/02. |
| Title: Water Combustion Technology - Methods, Processes, Systems and Apparatus for the Combustion of Hydrogen and Oxygen | § | |

## DECLARATION OF RICHARD ALAN HAASE

My name is Richard Haase. I am of sound mind, capable of making this Declaration and have personal knowledge of the facts stated herein.

1. I am the President of ClearValue, Inc. and the owner and inventor of U.S. Pat. Application No. 10/790,316.

2. I am the custodian of the patent files associated with this application and with the files associated with all applications of which this application claims priority. I am also the custodian of the business files for ClearValue, Inc., as well as those ClearValue, Inc. associated with this application and with the files associated with all applications of which this application claims priority.

3. I know of no teaching, publication or application for patent prior to my teaching which teaches or suggests the formation of a hydrogen gel by placing frozen water crystals within gaseous hydrogen.

4. I know of no teaching, publication or application for patent prior to my teaching which teaches or suggests the formation of an oxygen gel by placing frozen water crystals within gaseous hydrogen.

5. I know of no teaching, publication or application for patent prior to my applications for patent which teach or suggest maintaining the combustion and/or the exhaust temperature of a hydrogen fueled jet engine by increasing the airflow and/or air compressor size of said jet engine over that which would normally be used for a kerosene fueled jet engine.

6. I know of no teaching, publication or application for patent prior to my applications for patent which teach or suggest maintaining the thrust and/or altitude ceiling of a hydrogen fueled jet engine by increasing the airflow and/or air compressor size of said jet engine over that which would normally be used for a kerosene fueled jet engine.

7. I know of no teaching, publication or application for patent prior to my applications for patent which teach or suggest maintaining the combustion and/or the exhaust temperature of a rocket engine by adding water to said combustion.

8. I know of no teaching, publication or application for patent prior to my applications for patent which teach or suggest maintaining the thrust of a rocket engine by adding water to the combustion of said rocket engine.

9. I know of no teaching, publication or application for patent prior to my applications for patent which teach or suggest the combustion of hydrogen with oxygen, wherein the oxygen is obtained by separation of air, and wherein said separation of air is powered or driven by said combustion of hydrogen.

10. Attached herein as exhibit A is a true and correct copy of an e-mail interchange that I had with Mr. James Kessling of the US DOD. As is obvious from the interchange, Mr. Kessling expressed numerous statements of disbelief for the technology taught and claimed within the styled patent application.

11. I hereby declare that all statements made herein are of my own knowledge are true and that all statements made on information and belief are believed to be true; and further these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issued thereon.

**Full Name of Declarant:** Richard Alan Haase

**Residence:** 4402 Ringrose Drive
Missouri City, Texas 77459

**Citizenship:** USA

**Post Office Address:** P.O. Box 18856
Sugar Land, Texas 77496-8856

**Date:** April 12, 2008

**Signature of Declarant**

Exhibit A

## Richard

**From:** Richard [richard@clearvalue.com]

**Sent:** Tuesday, June 12, 2007 9:25 AM

**To:** 'Kiessling, James CIV MDA/DV'

**Cc:** 'Myrick, Erwin CIV MDA/DV'; 'Hargenrader, Louis A CTR MDA/DV'; 'Koskey, Paul CIV MDA/DV'; 'Appler, David DUSD, Advanced Systems & Concepts'; 'George Ulrich'

**Subject:** RE: 35 USC 103(a) Obviousness - Traversal by Skepticism of Experts

**Importance:** High

Mr. Kiessling:

Oops, I pushed to far and do apologize if I insulted you.

From your background, I agree. You are not one of expert or ordinary skill in the art of combustion engines or of jet propulsion or of HVAC Systems or of Power Plants. Therefore, there is no value in my presenting your skepticism to the US PTO. However, you do have an impressive background in the areas for which you practice.

Your thoughts in relation to an article are good. Unfortunately, I and my team, have been so side tracked in relation to enforcing patents against France (and we had better wake up to the fact that France, the government, is supporting major French Companies in obtaining control of water resources world wide; such will lead to significant political unrest. Water and pure water should be a fundamental human right and not a privilege to those who can afford it. Allowing pure water to become a resource of the wealthy or those of privilege will cause humanity significant issues!)

While an article will do much for a peer review, it unfortunately will not do much for the current US PTO Office Action which I need to answer in a matter of weeks; there is just not enough time. Thank you for the thought though.

If I may, I must though correct, the patent specification has already passed a 35 U.S.C. 112 review by both the Office of Initial Patent Examination (OIPE) and the Patent Examiner. There is no question as to the invention teaching one of ordinary skill in the art how to practice the invention. Further, again, Great Britain has already allowed a set of claims as presented in my last e-mail. So, I cannot agree; two capable and respected patent offices do not have the same opinion.

If the DOD wishes to obtain the Proof-of-Concept Units I described, that is the cost.

If the military is not a suitable market for hydrogen combustion systems and hydrogen combustion systems are the next generation of combustion systems, then it is entirely possible that the US will be taken over by other nations that can adapt. Is the US Military becoming a dinosaur? The US Military has historically been capable due to technology. Has such a capability to change and to think been lost in the US Military? If so, should I learn to speak Chinese or Farsi?

a. I am sorry, but I do not teach the requirement of high pressure $H_2$; nor do I teach the requirement of high pressure $O_2$ or of liquid $O_2$. I only teach the requirement of cryogenic $H_2$, which does not have to be liquid, just stored preferably at near 100 R.
b. Again, if a strategic advantage/disadvantage is the issue, cost to change is a question of horse

vs. motorized transportation. Remember WW I and the old Cavalry. We had to change or loose. Assuming that my presentation is correct, we either change or become second rate. I do not prefer to become second rate. As far as safety, H2 is much safer than diesel. That is without question.

c. Again, I am not recommending high pressure, I am recommending cryogenic temperature. Big difference. Anyway, diesel is a high molecular weight fuel compared to H2; therefore, in an explosion it spreads near the surface of the earth, similar to, what was that stuff, Napalm (sp.). In strong contrast, H2 literally distills to the upper atmosphere in seconds. The Hindenburg did not blow due to H2, it blew due to paint pigmentation and static charge.
d. Insulation. The Carnot Cycle.
e. Again, I am not presenting the storage of O2, except in limited quantities after the O2 is distilled from air. Again, H2 is a low boiler, the lowest; therefore, H2 will immediately travel to the stratosphere. (Just like a distillation column.)
f. OK, lets go though it again. The WCT has 4X the fuel efficiency while the H2 fuel has 3X the energy per pound and the engine has up to 10X the power per CID. This is all while composites are currently used to store H2. Yes, there will need to be some work; however, said work is not beyond the skills of one who is of ordinary skill in the art.

If you believe that US Politics have nothing to do with $3.50 per gallon gasoline, then ? If you believe that the concentration within the oil industry, e.g. Exxon-Mobile, Texaco-Shell, Chevron-Phillips, etc. has nothing to do with politics then ? What about the Sherman Act?

I complement you on your accomplishments and your tenacity. I also have rather accomplished commercialization experience with DuPont, GE Plastics and my innovations with ClearValue. Please appreciate though, that the "individual" components to the WCT already exist, e.g. cryogenic distillation of air, internal combustion engines, cryogenic storage of hydrogen in a composite storage tank, steam driven turbines and generators, electrolysis, etc. The innovation in the WCT is in the thermodynamics while the engineering is rather straightforward. And, given that said innovation goes against many established paradigms for which these e-mails establish in detail, said innovation creates skepticism.

In short, GM is stupid. Ford is asleep. Chrysler is recovering. And, it appears as though the US Military is resistant to change. Therefore, please appreciate that if the WCT is commercialized with a foreign company, that the US Military was afforded the opportunity in the beginning. Again:

a. Planes with 3X the flight distance,
b. Tanks, trucks and support vehicles with 10 X the distance,
c. 90 percent reduction in fuel poundage,
d. Local fuel generation and supply,
e. Significant increase in engine power (5 – 10 X is feasible),
f. Significant reduction in engine size and weight,
g. Limited to no production of COX, SOX or NOX.
h. etc.

I hate to say it, but I think that I need to learn a foreign language.

Regards,

RA Haase

Richard A. Haase, President & CEO

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-----Original Message-----
**From:** Kiessling, James CIV MDA/DV [mailto:James.Kiessling@mda.mil]
**Sent:** Monday, June 11, 2007 4:54 PM
**To:** richard@clearvalue.com
**Cc:** Myrick, Erwin CIV MDA/DV; Hargenrader, Louis A CTR MDA/DV; Koskey, Paul CIV MDA/DV; Appler, David DUSD, Advanced Systems & Concepts; George Ulrich
**Subject:** RE: 35 USC 103(a) Obviousness - Traversal by Skepticism of Experts

**Sir**

**1) I would not cite myself as having "expert skill" in the art if you mean engines/thermodynamic systems; I am merely aware of major factors in selection and use of systems.**
**- By education I have a degree in Geophysics (Geophysics and Space Physics Specialty) and I have spent the last 23 years in Aerospace (industry and government) analyzing and building systems including sensors and rockets. I would be classed as a senior level systems engineer / systems architect in missile defense and space / airborne systems. For specialized application issues I usually bring in a university researcher or staff member from one of the National labs to address specific issues within their area of specialty.**

**If you want a "real expert's" skepticism, you might try writing an article on your proposed engine / cycle and submit it to a peer reviewed academic journal in combustion / chemical physics and either get it accepted or use the peer review results as your "expert's skepticism" notification.**

**2) I stand behind my statements in the emails (which I copied you as a courtesy to show that indeed the Government had looked at your idea). The particular issue I really emphasize is "lack of clarity of the concept and breadth of claims without completeness of the concepts to actually make an estimation or proof of any of the improvements that you cited."**

**Insufficient material was available to fully appreciate an end-to-end system and the material that was provided talked variously to different families of concepts without clear delineation. The diagrams can apply to several implementations (with or without a steam turbine and condenser for example). Thus the comment is not about obviousness, the concept is vague as described and I am reasonably certain that a working device resembling your claims could not be fabricated using the engineering material provided. If the material is not descriptive at an engineering level; then no invention exists.**

**Your comment as to the needed investment of 200K dollars to reach a working model in six months is essentially spurious marketing as it was mentioned without any supporting evidence such as engineering cost estimates to perform necessary detailed design engineering; mechanical design, parts fabrication, assembly and initial testing. If the initial device for proof of concept was this affordable, why didn't you just build it to show as part of your marketing effort and attempts to secure intellectual property rights? I know that it is trivial to borrow that level of money with personal goods as security with most any commercial lending establishment. Rather than attempting to "browbeat" the military to invest in vague marketing claims, if the working model is this affordable and quick to build, you could "put your money where your mouth is" and bet on the technology yourself and generate a working device that removes the need for unsubstantiated claims.**

**If you were presenting an idea with a working model of that idea that could be assessed for efficiency and accuracy of your claims, that would be a far different situation from the present**

**where you are presently making claims to a concept that has not been reduced to practice.**

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The military is also not a suitable market for hydrogen combustion based systems, so we are not a suitable investor in any case as it does not address our interests.

You do not require specialized understanding of the military in order to understand why any military would be extremely adverse to the use of H2 and O2 as vehicle fuel systems:

a) The new requirement for either high pressure H2 (and potentially O2g) or cryogenic LH2 / LO2 to fuel vehicles / provide for power needs
b) The costs (and risks) to address the local generation of H2 (and potentially O2)
c) New vulnerabilities of vehicles with high pressure tankage to projectile weapons (rupture of vessels at high pressure is extremely lethal to nearby personnel)
d) Energy costs and additional logistics to maintain refrigeration on either or both LH2 / LO2 (otherwise cryogenic liquids will.be rapidly lost to boil-off)
e) Safety issues associated with H2 and O2 in vehicles, specifically new flammable vapors that are not presently accounted for in operational settings.
f) The new mass of pressure vessels or insulated storage tanks is not trivial and must be accounted in the power to weight ratio of vehicles using Hydrogen fuel. I expect a very serious mass penalty in fuel / oxidizer tank weight for vehicles such that the result of going to Hydrogen combustion would incur performance penalties for the overall vehicle. Additionally, a 50 gallon tank to carry 1.7 kg of H2g at 100 atmospheres pressure is a very poor substitution for 190 kg of diesel fuel at STP even if you want to argue that H2 has 3x the power per mass. Your vehicle design could not include both significant range between refueling and any significant cargo capability. Volume matters and it matters a lot especially when the storage tank walls must be strong enough for appropriate safety margins for pressure vessels.

I am reasonably certain that the use of diesel fuel and gasoline by militaries world-wide, which are commonly available from many sources both locally and in potential conflict theaters, has nothing to do with US politics. The commonality of the vehicles, the high volumetric energy storage, liquid transfer (and low flammability for Kerosene) makes transport and handling known quantities. Onsite generation of H2 / O2 cannot be thought of as being portable activities and would present significant logistics issues to create local generation capabilities regardless of the original source of power.

Finally your comments as to "any innovation has obstacles to overcome (logs in the road so to speak)..." are both trivializing the process of engineering and insulting to me personally. I am very aware of the issues involved in innovation of a new product against significant political and technical resistance. From 1998 to 2002 I created the concept, led engineering detailed design and systems integration and flight testing to create the worlds highest performing airborne infrared telescope and camera system. I experienced all the issues with bringing a new innovation to completion in a rather hostile environment including personal attacks and as a result I give all concepts brought before me complete and unbiased reviews.

If after consideration of all of the above, you persist in a desire to use my comments and analysis in pursuit of your unsubstantiated claims, I insist that you provide the reviewer with all of my material including this email without alteration so that I will not be miss-quoted or quoted out of context.

Jim

James Kiessling, MDA/DV
(703) 980-4599 (Cel + Vmail)
(703) 882-6892 (desk)

-----Original Message-----
**From:** Richard [mailto:richard@clearvalue.com]
**Sent:** Friday, June 08, 2007 1:09 PM
**To:** Kiessling, James CIV MDA/DV
**Cc:** Myrick, Erwin CIV MDA/DV; Hargenrader, Louis A CTR MDA/DV; Koskey, Paul CIV MDA/DV; Appler, David DUSD, Advanced Systems & Concepts; 'George Ulrich'

**Subject:** RE: 35 USC 103(a) Obviousness - Traversal by Skepticism of Experts
**Importance:** High

Mr. Kiessling (or is it Dr.):

I understand that you cannot endorse the use of your statements for someone else to obtain a patent. However, if I may:

1. Are you one of expert skill, or at least ordinary skill, in the art? and
2. Do you stand behind your statements or do you retract any of your statements?

I don't want to be a lawyer, but it is that simple. You were rather critical in your e-mail of the technology; this is while skepticism of experts is an excellent method of proving to the Examiner that the instant invention is "not obvious". Please refer to the MPEP Section 716, attached.

If I may, a patent application is not necessarily a "proof", if that is what you are seeking. However, if I may, you were pretty direct attacking the physics and the energy balances. Such would be reasonably concluded as "skepticism".

As far as the claims go, claim approval is a negotiation process between the inventor and the US PTO; as such, you start with a rather significant breadth and then you negotiate. For your information, a copy of the claims allowed in Great Britain is attached. We will obtain at least the same breadth in the U.S. in our first set of claims; we have six sets pending in the first U.S. Application with a second grouping to be sought from PCT/US06/048057, e.g. "The Haase Cycle".

Again, if I may, a working model would be excellent. If it were not for the <u>damn French Water Companies</u> infringing my other IP, many models would be completed. If the military can invest $200,000, we can complete both an internal combustion engine vehicle and a jet engine model plane, e.g. proof-of-concept, within 6 months.

As far as originality goes, I believe that if you look at the instant claims, attached, as well as the energy management systems, that there is novelty over the steam engines of the 18'th century.

As far as water injection and pitting goes, please refer to the section in the patent application regarding water chemistry. One good treatment additive to eliminate pitting is hydrazine at ppm concentrations, while there are chemical additives which are normally practiced in the water (boiler) industry.

If I may, any innovation has obstacles to overcome (logs in the road so to speak). I would like to suggest that for any innovation to commercialize one needs to look primarily at the road with your destination in mind; this is while you navigate the logs, so to speak. As, if you focus on the logs, it is easy to forget where you are going and become discouraged.

If I may, there are desires (or wants), then there are needs and strategic advantage. The desires sound rather aligned with Exxon (which stands to reason with Chaney as the VP at this time); however, when this technology takes hold (and it will), the real question is one of strategic advantage versus strategic disadvantage. If there is any

truth in your mind at all, or perceived risk for that matter, in relation to the WCT, then it would not be in our best national interest for say China or Russia to convert to the instant invention while the US Military is still being courted by Exxon (inside or outside of the Whitehouse). I do not wish to be rude, but I do wish to put this on the table in a way so as to obtain attention.

Further, if I may, I agree that the volumetric energy storage is less; however, if the engine is near ½ to ¼ the size with more power, who cares? Further also, Work = force X distance = mass X acceleration X distance; therefore, volume is not a part of the equation. What is important is that hydrogen has literally three (3) times the energy per pound, while the engines I propose can have 10 X the power per CID (that is with engine structural enhancement).

In relation to the reactors; yes, they are today on ships; so, use them as needed or place on land as needed (logs vs. the road and the destination).

I have never had a single class in military strategy or in military logistics. However, it makes sense that a "local" source of fuel would reduce the "footprint" or the "enemy target". I would think that the "potential mobility" of the fuel source would have a strategic advantage as well. Again, though, I have had no military training.

Before wishing you a nice day, though, if you are:

1. Not one of expert skill in the art, please inform,
1. Not one of at least ordinary skill in the art, please inform,
2. Retracting any portion of your eight previous statements, please inform.

So, if you need to answer yes to any of these questions, please inform within 10 business days.

Otherwise, I do believe that your "skepticism" is in my best interest with the US PTO.

So, have a nice day. And, I look forward to speaking with your in the future, if a possibility.

Regards,

RA Haase,

Richard A. Haase, President & CEO

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-----Original Message-----
**From:** Kiessling, James CIV MDA/DV [mailto:James.Kiessling@mda.mil]
**Sent:** Thursday, June 07, 2007 3:41 PM
**To:** richard@clearvalue.com

**Cc:** Myrick, Erwin CIV MDA/DV; Hargenrader, Louis A CTR MDA/DV; Koskey, Paul CIV MDA/DV; Appler, David DUSD, Advanced Systems & Concepts; George Ulrich
**Subject:** RE: 35 USC 103(a) Obviousness - Traversal by Skepticism of Experts

Mr. Haase;

I cannot endorse the use of my critique as a means to promote a patent application for a concept-only approach such as you are promoting.

I believe that my objections had to do with lack of clarity of the concept and breadth of claims without completeness of the concepts to actually make an estimation or proof of any of the improvements that you cited.

I believe an actual working model that can be tested to demonstrate the specific system level efficiency is required for complex mechanical constructs. Construction of such a model would force consideration of all aspects of the technical base and would eliminate the necessity of unsubstantiated claims as to lower losses / higher efficiencies of hydrogen combustion with water injection. Such a working model could provide direct evidence of end-to-end efficiency via independent supervision of tests that compare the chemical energy of the hydrogen fuel provided with the mechanical work delivered. (Equivalently the electrical energy in Joules if you choose to deliver electrical output could be compared with the fuel chemical energy).

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I am not a patent examiner nor do I have expert knowledge of how the patent examiners review patent applications, however; I do not believe the material you developed is entirely original:

Per Wikkipedia:
In 1807, François Isaac de Rivaz built the first hydrogen-fueled internal combustion vehicle

Use of the reciprocating piston engine principal with H2Og (steam) as a working fluid and a separate condenser is essentially the Watt engine from circa 1770. Your modification is that heat is applied by the simultaneous combustion reaction of $2H2 + O2 \rightarrow H2O + E$ within the expansion cylinder. Significant examples of use of a working fluid (steam in your case) is covered in the Rankin and Kalina cycles that employed external combustion and the use of water phase changed to steam. The presence of liquid water injection in your proposed engine is a technical risk for corrosion / pitting if the water is not fully vaporized. I am aware of the use of water injection to provide short term boosts in output from WWII fighter aircraft engines and other piston engines and I am unaware of the patent or "common practice" status of those approaches and whether hydrogen as a fuel is covered in prior art. Further the use of reciprocating engines with steam was largely replaced with steam turbines for efficiency purposes in better converting chemical energy of fuels (heat) to mechanical energy of rotation.

Also per Wikkipedia a patented "6-Cycle" engine has similarities to your concept and insight as to issues of water purity and lubrication issues that your proposed engine must contend with: http://en.wikipedia.org/wiki/Crower_six_stroke . Further, I would note that his patent application was for a device that he had actually built.

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Stepping away from the engine itself; as a systems level analyst, I cannot agree that Hydrogen combustion technology has benefits for DoD as you would state for the following reasons:

1) The logistics train is entirely new; DoD does not presently use H2g or LH2 for vehicle fuels in remote or battlefield settings
2) The volumetric efficiency of energy storage of even liquid hydrogen is at best 25% of the energy storage of conventional hydrocarbons (Liquid H2 is only 7% the density of water) and must be maintained in a refrigerated and pressurized

vessel at less than 20Kelvin.

3) Gaseous H2 is substantially worse in volumetric energy storage, at STP H2 is 2 grams / mole into 22.4 liters, at 100 atmospheres (a rather hazardous pressure vessel) 22.4 liters holds 200g or a 50gallon (~3.8 liter / gal) capacity H2 tank holds only 1.69kg of H2.
4) The requirement that you have implied to generate the Hydrogen (and preferably Oxygen) at/near site of use creates a new class of problems to solve in the portable generation of electrical power in theater. (Your suggestion that "You guys are good at nuclear fission, good at small nuclear reactors. A small portable nuclear reactor in combination with an industrial grade electrolysis cell would localize fuel development and efficiently produce H2 while removing a significant foot print target." misses this issue as the only "small portable reactors" that I am aware of in DoD are self-propelled as the power-plants of Submarines and Aircraft Carriers.)
5) The characteristics of fuels that would be inherently desirable to DoD are as follows: Compatible with existing types of storage and transport infrastructure, higher energy density than gasoline/kerosene (volumetric and per mass), equivalent or better handling and safety characteristics (ambient pressure storage, no cryogenics, and non-toxic). Your proposed engine and related infrastructure do not address these inherent DoD desires or improve any of the issues that you cited.

The so-called Hydrogen economy has a number of issues that make it marginal/ non-practical for domestic applications and certainly myself and others consider it impractical for warfighting applications (combat is about controlled destruction and is inherently "non-environmentally friendly"). I close with another pair of quotes from Wikkipedia:

"Elemental hydrogen from solar, biological, or electrical sources costs more in energy to make than is obtained by burning it. Hydrogen may be obtained from fossil sources (such as methane) for less energy than required to make it, but these sources are unsustainable, and are also themselves direct energy sources (and are rightly regarded as the basic source of the energy in the hydrogen obtained from them)."

"Hydrogen used in transportation would burn cleanly, without carbon emissions. However, the infrastructure costs associated with full conversion to a hydrogen economy would be substantial.[36] In addition, the energy density of hydrogen gas is significantly less than that of traditional fuel sources, unless the hydrogen is stored at extremely high pressure."

Jim

James Kiessling, MDA/DV
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(703) 882-6892 (desk)

-----Original Message-----
**From:** Richard [mailto:richard@clearvalue.com]
**Sent:** Wednesday, June 06, 2007 1:31 PM
**To:** Kiessling, James CIV MDA/DV
**Cc:** Myrick, Erwin CIV MDA/DV; Hargenrader, Louis A CTR MDA/DV; Koskey, Paul CIV MDA/DV; Appler, David DUSD, Advanced Systems & Concepts; George Ulrich
**Subject:** 35 USC 103(a) Obviousness - Traversal by Skepticism of Experts
**Importance:** High

Mr. Kiessling:

The attached E-Mail which you sent to me on 05/28, along with my responses of 05/28 and 05/29 appear to be information for which I should forward to the US PTO regarding the subject and U.S. Pat. App. 10/790,316.

In summary, the US PTO Examiner does understand the hydrogen engine technology presented in 10/790,316 (The Water Combustion Technology (WCT)) which I presented at the Showcase and for which we seem to be having technical challenges. The US PTO Examiner is currently presenting to me a prime facie case of obviousness as referenced in the subject.

A very good method of traversing a 35 USC 103(a) rejection is by documented skepticism of experts. The e-mail communication which you sent to me and attached would certainly fit such a description. Further, I would hope and trust that the DOD would present such a technology to an expert within the military for review and comment.

In light of all of the above, I plan to send the attached in a declaration of authenticity to the US PTO; as again, the attached comments from one of expert skill in the art would definitely prove that the instant invention (10/790,316) is not at all obvious. (Ref. Manual of Patent Examination Procedure (MPEP) 716, which is available at uspto.gov)

Should you have any issue with my sending to the US PTO, or more importantly, any issue relating to any statement contained in your e-mail or any issue as to your position as one of expert skill in the art, a return communication would be most appreciated within 10 business days.

I trust that should I not receive any communication from you within 10 business days that it is safe to assume "You stand by your comments and that you are one of expert skill in the art".

Respectfully yours,

RA Haase

Richard A. Haase, President & CEO

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Sugar Land, Texas 77496-8856

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## Richard

**From:** Richard [richard@clearvalue.com]
**Sent:** Wednesday, May 30, 2007 6:41 AM
**To:** 'Kiessling, James CIV MDA/DV'; 'Myrick, Erwin CIV MDA/DV'; 'Hargenrader, Louis A CTR MDA/DV'; 'Koskey, Paul CIV MDA/DV'
**Cc:** George Ulrich (george.ulrich@clearvalue.com); David A. Appler (David.Appler.ctr@osd.mil)
**Subject:** Benefits of the WCT to the US Military
**Importance:** High

Military Managers:

Let me briefly present the benefits of the WCT, assuming that my thermodynamics are correct or at least partially correct (and I realize that we have a way to go for a consensus understanding).

Today, your fuel drivers, diesel and gasoline, are huge targets. Today, you must transport fuel from a refinery to the battle field. Logistics are not just important, logistics are an enemy target. By utilizing H2, the military could simply locate a local water source for H2 development **on site**. You guys are good at nuclear fission, good at small nuclear reactors. A small portable nuclear reactor in combination with an industrial grade electrolysis cell would localize fuel development and efficiently produce H2 while removing a significant foot print target.

Today, your engines, diesel and gasoline, only produce about 15% usable energy of the energy combusted. That is not good. By using the WCT with an estimated efficiency of near 50 to 60 %, you would reduce your fuel requirement by near 75 %. Further, H2 has 3 times the energy per pound as compared to any hydrocarbon; that is another reduction of 66%. Therefore, by using the WCT, the military can reduce its fuel requirement, in poundage, by about 90 % (1/(4 X 3) ≈ 1/10). That is a significant reduction in both supply lines and in storage.

Today, your engines, diesel and gasoline, aspirate with air at atmospheric pressure. The WCT provides pure O2 at pressure. Think about it for a moment. While most believe that their vehicle is limited by fuel, it is not; it is limited by air or the amount of O2 available. The WCT changes that relationship. The WCT, while obtaining liquid O2 from distillation can easily support a pressurized O2, oxidizer, intake. Also, since the WCT has nearly no N2 in the combustion cylinder, there is near an 80% (4 to 1) improvement in utilization of cubic inch displacement as air is only about 20 % O2 while being near 80% N2; this is while N2 at best does nothing except throw away combustion energy (and make NOX). Therefore, just by removing the N2, we get a 4 to 1 increase in available torque (or horsepower). Then by pressurizing the combustion chamber with O2 at say 30 psig, we obtain another 3 to 1 increase in power. (It goes that the H2 is added at pressure as well. BMW is starting to figure this out.) I have just described a power increase which is near 10 to 1 (3 X 3). Therefore, with the WCT, the military could reduce engine size, thereby reducing engine weight while simultaneously increasing engine power. The trick is going to be in engine structural design as the stresses imposed will also be much greater.

Today, your engines, diesel and gasoline, operate off of the Otto Cycle, e.g. power = the change in pressure times the change in volume within a combustion cylinder. The WCT can incorporate the Haase Cycle, wherein during exhaust water is added to the combustion chamber in order to further reduce combustion pressure (PV=nRT). Then, during a very slow burn (H2 is good at that) there is added to the combustion cylinder at least one of fuel (H2) and oxidizer (O2), thereby extending the

high pressure envelope. While exaggerated for demonstration purposes, please refer to the attached.

Today, your jet engines operate with kerosene. In strong contrast to kerosene, H2 has 3 times the energy per pound. Simple math means at least 3 times the time between refueling. Simple math means an increase in load carrying capacity. Now, for the best part, some of that reduction in fuel weight can be used to store water (H2O). As jet propulsion is a momentum equation, e.g. mass times velocity, temperature is really irrelevant to the movement of the plane. Therefore, it is possible with a H2 jet engine to locate a jet exhaust cooling compartment just prior to jet engine exhaust. Within such a compartment, the heat signature or jet engine exhaust temperature can be reduced. Such would be good for our military pilots as well as our commercial airliners. I do not know much about heat seeking missiles; but I do know that we can reduce the temperature, e.g. heat signature. You guys will have to determine if we can reduce the temperature enough as compared to the required amount of water to remove the target from the missiles heat sensor.

So, in summary, by using the WCT, with our without the Haase Cycle, it is possible for the military to:

1. Significantly reduce supply lines, along with the fuel footprint in the field,
2. Reduce fuel usage, storage and transportation by near 90 %,
3. Increase ground equipment usefulness between refueling by about 1000%,
4. Increase engine power per CID by near 10 times (structural issues may limit, depending upon application),
5. Increase at least one of flight time between refueling and load carrying capacity of aircraft, and
6. Potentially reduce to maybe eliminate jet engine heat signatures on aircraft.

Those are a lot of significant benny's. We would like to work with you guys, if we can get past an understanding of the thermodynamics. Again, I await your response.

Regards,

RA Haase

Richard A. Haase, President & CEO

ClearValue, Inc.
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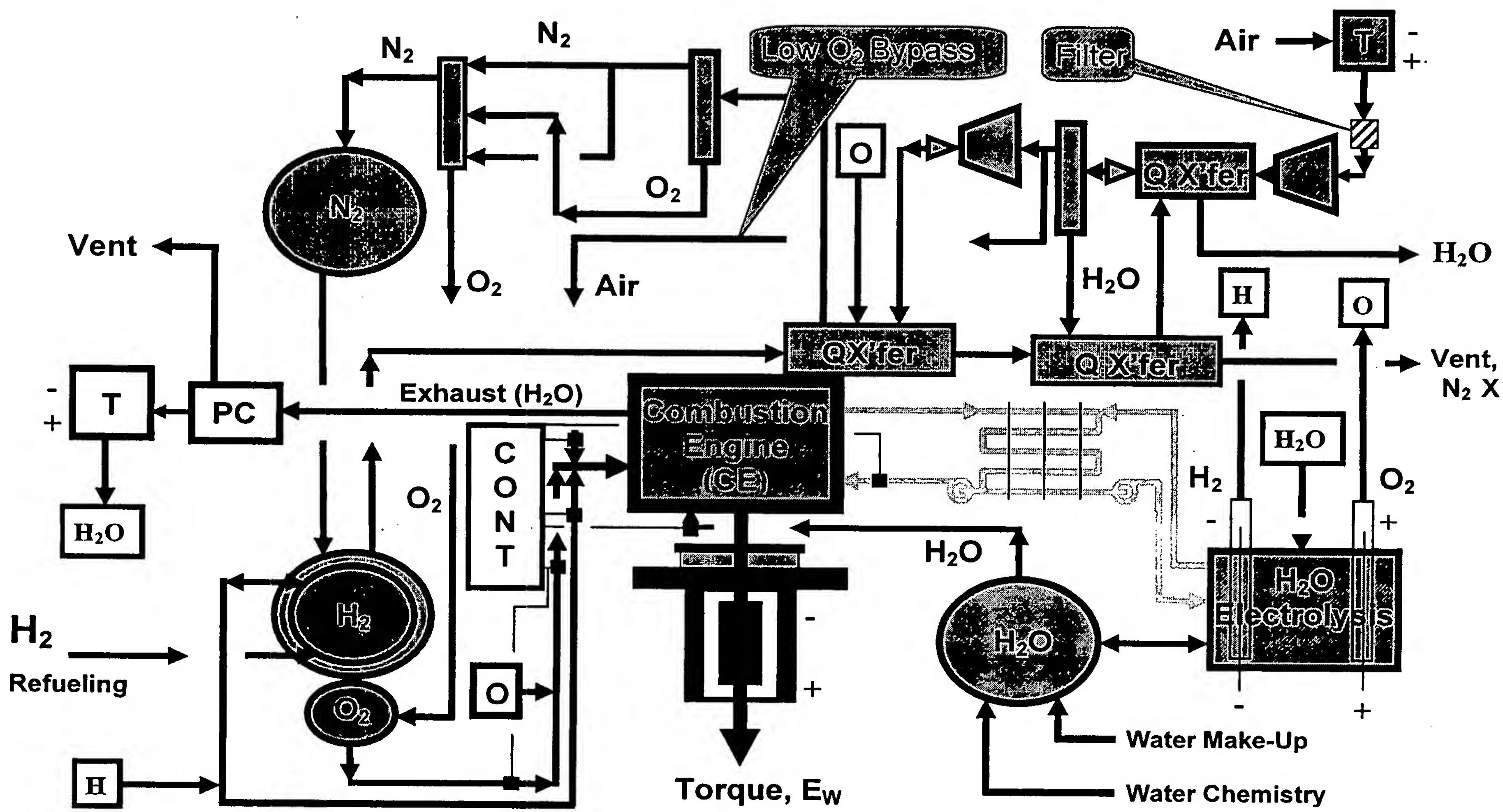
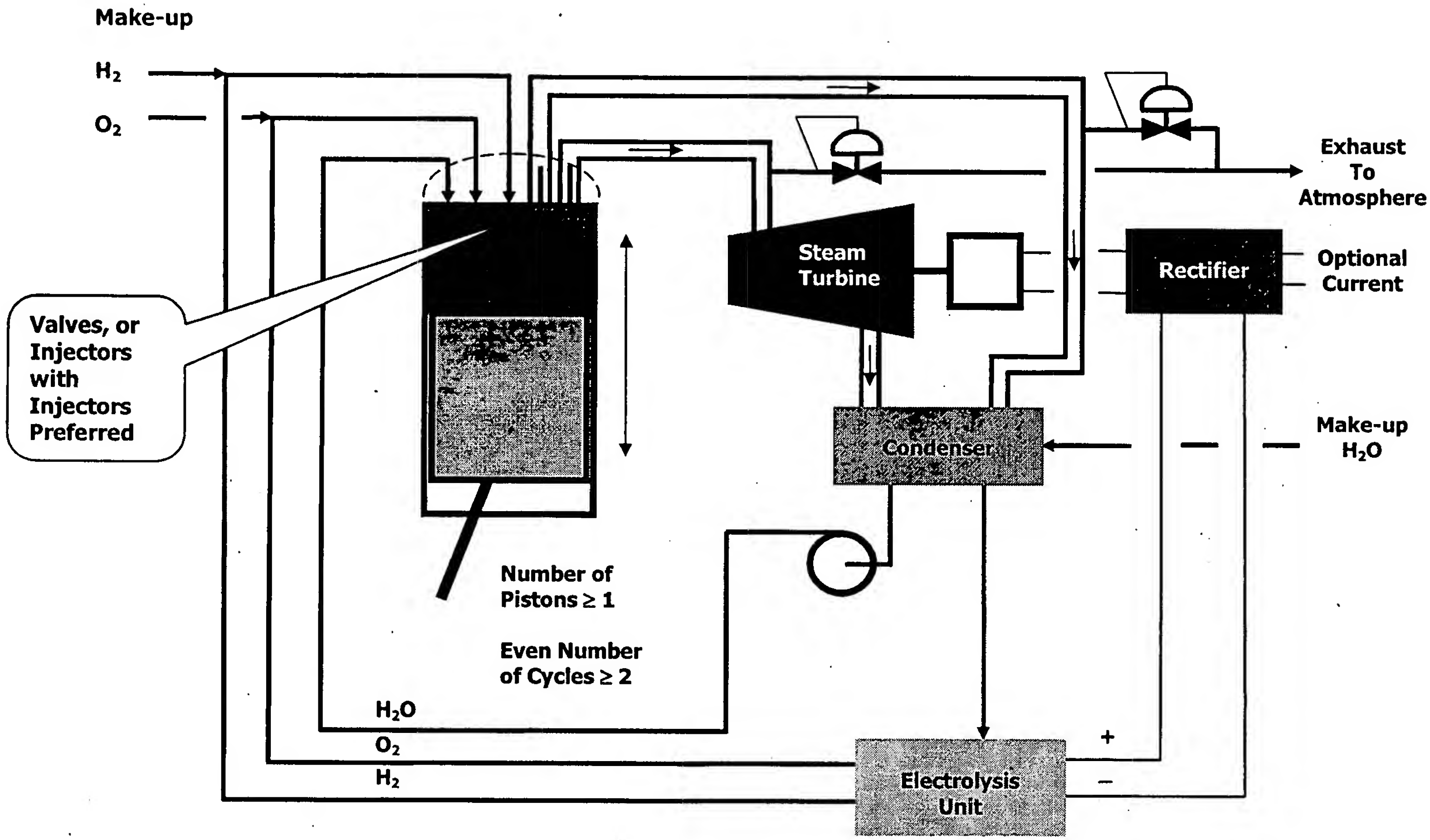
# ICE - Energy & Material Flow Diagram



# ClearValue's ICE Incorporating "The Haase Cycle"




Spark Ignition is Optional

**Richard**

**From:** Richard [richard@clearvalue.com]
**Sent:** Tuesday, May 29, 2007 9:24 PM
**To:** 'Kiessling, James CIV MDA/DV'; 'Myrick, Erwin CIV MDA/DV'; 'Hargenrader, Louis A CTR MDA/DV'; 'Koskey, Paul CIV MDA/DV'
**Cc:** George Ulrich (george.ulrich@clearvalue.com); David A. Appler (David.Appler.ctr@osd.mil)
**Subject:** RE: ClearValue's Hydrogen Engine - The Water Combustion Technology (WCT)
**Importance:** High

Military Managers:

I thank you for your attention to ClearValue's Water Combustion Technology (WCT). If I may, let me please respond directly to the comments posed:

1. I am sorry, but neither 35 U.S.C., 37 CFR nor the Manual of Patent Examination Procedure (MPEP) require the type of detail suggested. (The US PTO has not required models for decades.) What is important by 35 U.S.C. and the MPEP is to teach the invention, which in this case is a thermodynamic redesign of combustion using hydrogen as the fuel and pure oxygen as the oxidant, such that one of ordinary skill in the art can practice the invention. In fact, the invention has already been awarded a British Patent, e.g. BP 2407372. At this time, the U.S. Application is in its third office action, wherein all of the prima facie' rejections of the Examiner have been thoroughly answered and traversed. We are also responding to our first office action in Canada, Russia, China, India, Indonesia, Japan, Germany, S. Korea and Mexico. Also, if I might, broad claims are what is sought by an inventor, while those who license tend to prefer narrow claims; the reason for such is obvious. In recent years claim scope has tended to be much narrower; this is because in recent years most of the patent applications have been improvements upon pre-existing technologies. A new, ground breaking technology, such as the WCT, has historically and should today have a much broader claim scope.
2. The Carnot Efficiencies and losses relating to cryogenic distillation are already known by one of ordinary skill in the art of cryogenic distillation; therefore, such is not required within the instant patent specification, especially since the prior art of cryogenic distillation is referenced. Having said all of that, the Carnot Efficiencies of the instant combustion system are obviously directly related to the combustion temperature and the exhaust temperature, which in the case of the Haase Cycle should be about (1,800 – 600)/2,000 X 100% = 60 percent. If you refer to the charts from the showcase, friction losses are presented as known in the industry, near 3 to 5 percent. As far as a complete energy balance goes, that would be rather application dependent for which we would welcome further discussions.
3. I am sorry; I hate to correct, but cryogenic distillation columns do normally discharge a liquid $O_2$ product while distilling a gaseous $N_2$ product ($N_2$ from the top of the column and $O_2$ from the bottom of the column). This is normal everyday practice in the chemical industry as performed by Air Products, BOC Gases and (even the French) Air Liquide. Such is easily accomplished because nitrogen has a Joule Thompson Coefficient which is near 4 times that of Freon (ref. CRC Handbook of Chemistry and Physics). In short, $N_2$ is very easily chilled at just 150 to 200 psig using the Carnot Cycle. If I may, let me refer you to: Flynn, Thomas M., *Cryogenic Engineering*, Dekker, 1996. This is a Library of Congress Book; so, access is relatively easy. However, the goal of the $N_2$ is not to be a liquid (while a liquid would be better for heat transfer efficiencies), the goal of the $N_2$ is to keep the $H_2$ below its Joule Thompson Curve, which is near 360 R at atmospheric temperature (in essence you cannot chill

$H_2$ until you get it under 360 R (-105 F) at atmospheric pressure). When $H_2$ has a positive Joule Thompson Coefficient, e.g. about below 360 R from about 1 to 20 atmospheres, $H_2$ is easily chilled for storage down to hear 100R.

4. Those energy losses occur because the $H_2$ is normally above its Joule Thompson Curve, e.g. STP, therein having a negative Joule Thompson Coefficient (Again, let me refer you to Flynn). Using the available cryogenic $N_2$, as discussed above, the energy to chill, store, $H_2$ at near 100 R is dramatically reduced, as the $H_2$ will have a positive Joule Thompson Coefficient. Therefore, the storage density of the $H_2$ is dramatically increased while the energy to chill the $H_2$ is dramatically reduced. **Fuel cells cannot do that as fuel cells do not have any cryogenic $N_2$ available.** (Again, let me refer you to Flynn and $H_2$ densities at near 100R).
5. I am sorry, but the water is necessary unless exotic materials are used. $H_2$ burns very hot, near 1700 F and will build easily to over 3000 F in a confined space. Also, one of the thermodynamic goals of the instant invention is the recycling of otherwise lost energy directly following the first and the second laws of thermodynamics. Today combustion engines loose near 70% of their combustion energy in the form of enthalpy lost from the block and the radiator along with enthalpy and entropy lost from the exhaust. The instant invention has an insulated block and recovers all of the then focused enthalpy and entropy losses from the exhaust. Today, we only obtain about 15% of the combustion energy at the wheels. The instant invention plans to recover and recycle 70% of the otherwise lost combustion energy (near 4.5 times the energy at the wheels); therefore, the water is necessary in order to manage combustion chamber temperature so as to limit the use of exotic materials while providing the capability of energy recycle (again, directly by the first and the second laws of thermodynamics). I do agree that there will be losses due to the latent heat of vaporization of water; however, those losses are made up many times over in the improved engine efficiency, e.g. from about 15% to near 60%. Again, there is little to no $N_2$ in the combustion chamber.
6. Our computer models do not indicate that such is an issue. Quite frankly, such cannot be an issue as today's engines, as inefficient as they are at 15%, have friction losses of near 3 to 5 %. If we are recovering near 70% of otherwise lost enthalpy and entropy, friction losses of 3 to 5 % are not an issue. This is especially the case with the Haase Cycle, wherein a hot cylinder is directly cooled with water injection in a non-combusting cycle. I suggest that you refer to "total" energy balances on the system rather than "relative" energy balances on the system as those might relate to a water cooled engine using a hydrocarbon.
7. The energy balances for the jet engine (not rocket) assume the same exhaust gas temperature as current. Therein is where the additional air is necessary. The additional air is not needed as an oxidizer (so go the misunderstandings of the past); in contrast, the additional air is needed to maintain exhaust gas temperature and thrust. Hydrogen has near 3 times the energy per pound as compared to any hydrocarbon; therefore, the heat balance with a jet engine designed for kerosene when using $H_2$ is way off, near 3X. To put the engine back into thermodynamic balance, the instant invention teaches that we simply need more air to both keep the thrust up and to keep the exhaust temperature in range. This aspect of the instant invention explains very well the difficulties of the past, e.g. previous hydrogen jet engines had too high of an exhaust temperature, had limited thrust and had a low altitude ceiling. Again, the instant invention solves all three challenges with an energy, thermodynamic, balance which states that we need increased to about 160% more air or a compressor with increased to about 160% greater capacity. Say, a J-6 compressor on a J-3 Engine when burning $H_2$. Also, please appreciate that the combustion envelop for $H_2$ is so much broader than that of kerosene, e.g. hydrocarbon; therefore, $H_2$ will burn at fuel to air ratios impossible with a hydrocarbon.
8. I agree. Therefore, it makes no sense to me why that NASA does not launch horizontally therein utilizing the atmosphere for both lift and oxidizer until the atmosphere is too thin to be of value. (Why don't you guys take off horizontally with missiles or ICBMs? You could get a

much greater payload and carry much less oxidizer. And, if you need sub-space altitude, you could limit the amount of oxidizer storage necessary.) The carrying of oxidizer does not make sense until a sub-space altitude is obtained. This is taught in the instant invention.

I am so sorry that the instant invention is not understood. I suggest that you go back to the fundamentals of thermodynamics therein referring to the heat balances and losses which occur in a hydrocarbon internal combustion engine, both internal combustion and turbine.

I have found that most often the comments you state indicate a less than fundamental review of the thermodynamics of combustion. If you go back to the fundamentals, you will see the WCT Engine. If you stay within the mindset of human experiences with hydrocarbon systems, it is difficult. Those that I have found to understand the instant invention the quickest tend to be Chemical Engineers with a significant background in thermodynamics. I have unfortunately seen aerospace and mechanical engineers to struggle.

I trust that I have not been rude. I have tried to communicate directly while not being rude.

I have found, though, that when I receive misunderstandings as stated in the attached e-mail in any of my previous inventions forward progress becomes difficult until commercialization happens elsewhere. Therefore, I suggest an improved dialogue so as to surmount said misunderstandings. If not, then, I do have interest from foreign companies. Sorry, but true. Detroit is today in a state of stupid. GM still believes in fuel cells. Ford is near broke. GE is trying to copy the WCT and not get caught. Boeing is upset because it is not their idea, e.g. NIH. So, what is an inventor to do. We will probably commercialize with a company from the Far East.

I would like to work with the military if we can create a dialogue to surmount said misunderstandings. I will await your communication.

Regards,

RA Haase,

Richard A. Haase, President & CEO

ClearValue, Inc.
P.O. Box 18856
Sugar Land, Texas 77496-8856

Phone 281-261-9543
Facsimile 281-261-6505

richard@clearvalue.com

-----Original Message-----
**From:** Kiessling, James CIV MDA/DV [mailto:James.Kiessling@mda.mil]
**Sent:** Tuesday, May 29, 2007 4:12 PM
**To:** Myrick, Erwin CIV MDA/DV; Hargenrader, Louis A CTR MDA/DV; Koskey, Paul CIV MDA/DV
**Cc:** richard@clearvalue.com
**Subject:** RE: ClearValue's Hydrogen Engine - The Water Combustion Technology (WCT)

Gentles

I was asked to review the material provided on "Water Combustion Technology", I reviewed the material provided and prepared the following comments. As a technical reviewer; I cannot recommend any specific actions or contracting decisions, however; I have a number of observations that may prove

beneficial to others including the author of the material.

1) In my personal experience, this is not a "standard" patent disclosure as to the breadth of claims and I expect that the patent office will decline it for lack of detail and realization (e.g. a working model should be provided for this types of complex system or industrial process patents)
2) The overall system is not indicated as the author fails to include the Carnot efficiencies or friction losses of the Cryogenic air distillation to obtain oxygen (PT diagrams there are very "illuminating") and a compilation of all processes and losses in the cycle needs to be shown.
3) The comment on using LN2 to provide refrigeration support for LH2 is not credible since at 1 atm the temperature of LN2 is 77K and H2 is liquid at 20K and heightened pressure. The critical point for LH2 is 33K and you cannot maintain liquid above this temperature.
4) According to commercial process sources, 30-40% of the energy value of liquid hydrogen is expending in compressing and cooling it to this level. LH2 is also at 7% of the density of water (STP) thus the volume of tankage is rather significant.
5) The use of water to provide cooling of the reaction process is actually counter-productive in a Carnot efficiency sense and unnecessary if the combustion reaction is 2H2 – O2 = H2O as that will not create NOx issues.
6) Using steam (H20g) as a working fluid that is due to the vaporization of water injection cannot be efficiently recovered in a condenser and recycled for additional efficiency in the manner indicated as the friction and Carnot losses will further reduce the value of the mass used.
7) In the "Rocket Equation" the key issues for the specific impulse of the propellant is due to exhaust gas velocity, first the average molecular weight of exhaust gasses should be minimized (inverse dependence on mass) (thus high fuel-oxidizer ratios, more fuel than stoichiometric balance for reaction due to low mass of hydrogen) and secondly higher temperatures of combustion (velocity goes as square-root of temperature ratio).
8) Carrying oxidizers for vehicles in the atmosphere decreases overall efficiency of the vehicle.

Bottom Line; I disagree with the author's physics and engineering approach for hydrogen combustion methods; however this is my professional and technical opinion for the reasons cited above.

For background reading of the "green" aspect of the so-called Hydrogen economy I recommend the "Bellona report" at http://bellona.org/filearchive/fil_Hydrogen_6-2002.pdf and I recommend accepting that it is an activist position piece but they did decent homework on the sources and uses of Hydrogen especially on vehicles.

Jim

James Kiessling, MDA/DV
Senior Advisor, Technology and Integration
(703) 980-4599 (Cel + Vmail)
(703) 882-6892 (desk)

>>>> snip <<<<<<

-----Original Message-----
**From:** Richard Haase [mailto:richard@clearvalue.com]
**Sent:** Monday, May 21, 2007 10:58 AM
**To:** Koskey, Paul CIV MDA/DV
**Cc:** George Ulrich; audrey@clearvalue.com
**Subject:** ClearValue's Hydrogen Engine - The Water Combustion Technology (WCT)
**Importance:** High

Mr. Koskey:

I do appreciate your time and interest in ClearValue and in the many technologies therein.

I must say that I did receive the same interest which you expressed from Raytheon regarding the subject in relation to a potential load/range improvement of the cruise missile. The same interest was expressed again by Mr. Paul M. Fritz at the Naval Air Warfare center in relation to drones.

Upon investigation, though, I find that if I file for an SBIR that the DOD will obtain a capability to use the technology license and royalty free. While I do not wish to do anything that may at all be considered business wise inequitable, if that information is correct, an SBIR may not be in my best interest.

For your convenience, I am attaching to this e-mail and electronic copy of:

1. The 4 page summary of the WCT presented at the showcase,
2. The 2 page summary of the Haase Cycle presented at the showcase,
3. Each chart presented in the ClearValue booth at the showcase,
4. My power point presentation, along with the associated script for the showcase, and
5. U.S. Pat. App. 10/, e.g. U.S. Pat. Pub. 20050198958.

Please inform of your thoughts.

Again, your interest in ClearValue and in ClearValue's technologies is genuinely appreciated. I trust that you had a timely trip home.

Regards,

*RA Haase,*

Richard A. Haase, President & CEO

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P.O. Box 18856
Sugar Land, Texas 77496-8856

Phone 281-261-9543
Facsimile 281-261-6505

richard@clearvalue.com

**Richard**

| | |
|---|---|
| **From:** | Richard Haase [richard@clearvalue.com] |
| **Sent:** | Monday, May 21, 2007 9:58 AM |
| **To:** | 'Paul Koskey (Paul.Koskey@mda.mil)' |
| **Cc:** | George Ulrich (george.ulrich@clearvalue.com); 'audrey@clearvalue.com' |
| **Subject:** | ClearValue's Hydrogen Engine - The Water Combustion Technology (WCT) |
| **Importance:** | High |
| **Contacts:** | Paul Koskey |

Mr. Koskey:

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Regards,

RA Haase

Richard A. Haase, President & CEO

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# ClearValue's Water Combustion Technology (WCT) – Hydrogen/Oxygen Engine

The combustion of fossil fuels is the combustion of HYDRO-carbons. ClearValue's Water Combustion Technology is the combustion of HYDRO-gen. The processes are chemically very similar.

$C_nH_{2n+2} + (2n+1)O_2 \longrightarrow nCO_2 + (n+1)H_2O + \text{energy}$
gasoline + 12.5 $O_2 \longrightarrow 8CO_2 + 9H_2O$ + 1,300 kcal
nat. gas (CH4) + $2O_2 \longrightarrow CO_2 + 2H_2O$ + 213 kcal

**Combustion of HYDRO-carbons**

$2H_2 + O_2 \longrightarrow 2H_2O + \text{energy}$
$2H_2 + O_2 \longrightarrow 2H_2O$ + 137 kcal
$H_2$ has 3X the energy per pound

**Combustion of HYDRO-gen**

In both cases, Oxygen ($O_2$) is the oxidant and Water ($H_2O$) is the combustion product. In hydrocarbon combustion, however, carbon does also combust to carbon dioxide ($CO_2$), a greenhouse gas. (During incomplete combustion, carbon does also combust to carbon monoxide (CO), a poisonous gas.) Unfortunately, to complicate matters, hydrocarbon combustion is performed with air instead of ($O_2$); this is while air is only about 20% $O_2$, being 80% nitrogen ($N_2$). A portion of the $N_2$ in air combusts endothermically (adsorbing energy) to produce oxides of nitrogen, $NO_X$ (NO, $NO_2$ and $NO_3$). While $NO_X$ is toxic to all life, $NO_X$ also catalyzes the conversion of $O_2$ to ozone ($O_3$). $NO_X$ and $O_3$ inhibit nature's ability to complete photosynthesis (Photosynthesis is the biochemical pathway utilized by plant life to convert $CO_2$ back into $O_2$). Further, $O_3$ is toxic at the Earth's surface, yet naturally produced from $O_2$ in the upper atmosphere to protect all life from UV radiation. Therefore, air pollution ($CO_X$ and $NO_X$) not only places greenhouse and poisonous gases in our air, air pollution also reduces nature's ability to replenish our air, e.g. $O_2$. Further, oil which is the raw material for: gasoline, diesel and kerosene, has sulfur as a natural contaminant. Sulfur combusts to form $SO_X$ ($SO_2$, $SO_3$ and $SO_4$). $NO_X$, $SO_X$ and $CO_X$ form acids with water, thereby creating acid rain. In conclusion, simply removing C, N and S from combustion removes $CO_X$, $NO_X$ and $SO_X$, acids and $O_3$ from our air.

## A Most Significant Challenge to Humanity

While humanity has been rather creative in the use of fossil fuel to provide energy, it is without question that said use will lead to environmental consequences; while, those consequences may be of biblical proportions. As the Earth warms, due to the release of $CO_X$ and $NO_X$ into the Earth's atmosphere, the Earth adapts to the warmth, increased energy, which exists in Earth's oceans and in Earth's atmosphere. That adaptation is causing changes in weather patterns, including record hurricane and tornado events, along with flooding and drought, depending upon location. Drought causes wildfires, while the flooding causes destruction of personal property. And, these events are seen with only a 1 ° C increase in the average Earth temperature. Should humanity not change in the use of fossil fuel to provide energy, computer models predict a 5 to 7 ° C increase in the average Earth temperature within the next 50 to 100 years. Only a 3 to 5 ° C increase in the average Earth temperature is required to melt Earth's glaciers and polar ice caps. Such a melting and thereby dilution of the salt content within Earth's oceans is predicted to stop the "warm water conveyance systems" in Earth's oceans. Should such a terrible event take place, we should bear in mind the significant heat sink which exists just outside our atmosphere, Space, wherein the temperature is only 1 to 3 K, e.g. – 450 to – 460 ° F. Having such an immense capacity to adsorb energy so close to home, it is not hard to imagine that if the extreme northern and southern portions of the Earth are not heated with the warm waters of the tropics that those extreme northern and southern portions of the Earth will cover with ice. Should humanity cause the next ice age, humanity will have caused their own calamity. And, should the "ice age scenario" not come to pass, that same melting of the glaciers and the polar ice caps will raise Earth's oceans by over 50 feet; such a rise in Earth's oceans would place many coastal cities under water while being a calamity of biblical proportions in its own right. The worst case scenario is a rising of the oceans followed by an ice age; in this scenario, humanity would leave the oceans for the higher altitudes. Once located in the higher altitudes, an ice age would be horrific.

**For our children, we must take action! We must replace fossil fuel energy sources! We must preserve our home!**

## Why Fuel Cells Are Not the Answer

While technically rather interesting, fuel cells were originally invented by NASA as an electricity source for spacecraft. Conceived for such an application, it should be appreciated that in combustion applications fuel cells are part of an electric motor, wherein fuel cells are used instead of batteries. Each fuel cell makes a small current; therefore, banks of fuel cells are required to produce energy of any significant quantity. Therefore, fuel cell energy is costly and complicated. Fuel cell engines have an installed cost that is 300% to 1,000% of that for combustion engines. This means that the cost of the average 200 HP internal combustion engine will increase from $3,000 to approximately $15,000 to $30,000 and the installed cost of power plants will quadruple. We cannot afford fuel cells to clean our air. If we must invest in fuel cells, we must endure either significant governmental underwriting and/or endure rather significant inflation. Lastly, fuel cells require platinum to be effective; this is while there is not enough platinum in the Earth's crust for one years automotive production.

## Technology Comparison

Energy management and efficiency are key. In efficiency, today's internal combustion engines (ICE) are only approximately 20%, electrical generating facilities approximately 30% and jet engines approximately 20%, efficient. These inefficiencies are easily understood by the first and second laws of thermodynamics, which define energy losses as forms of mechanical energy (torque), heat energy (enthalpy) and exhaust gases (enthalpy and entropy). That hot engine (enthalpy), that

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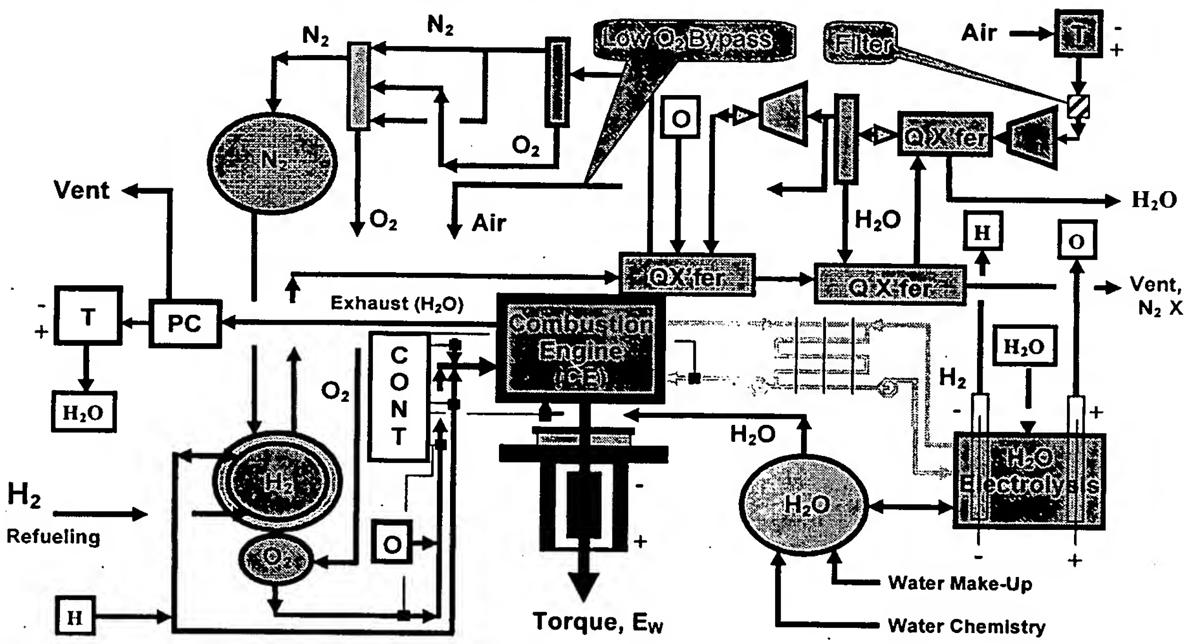
smelly (entropy) and hot (enthalpy) exhaust and sitting in that stalled traffic (torque) are all wasted dollars. Out of Every $1.00 of fuel placed in an automobile or truck, $0.80 is wasted. Out of every $1.00 spent on your electric bill, $0.70 is wasted. Between pollution and economic issues, we could do much better; the hydrocarbon combustion process is not very intelligent.

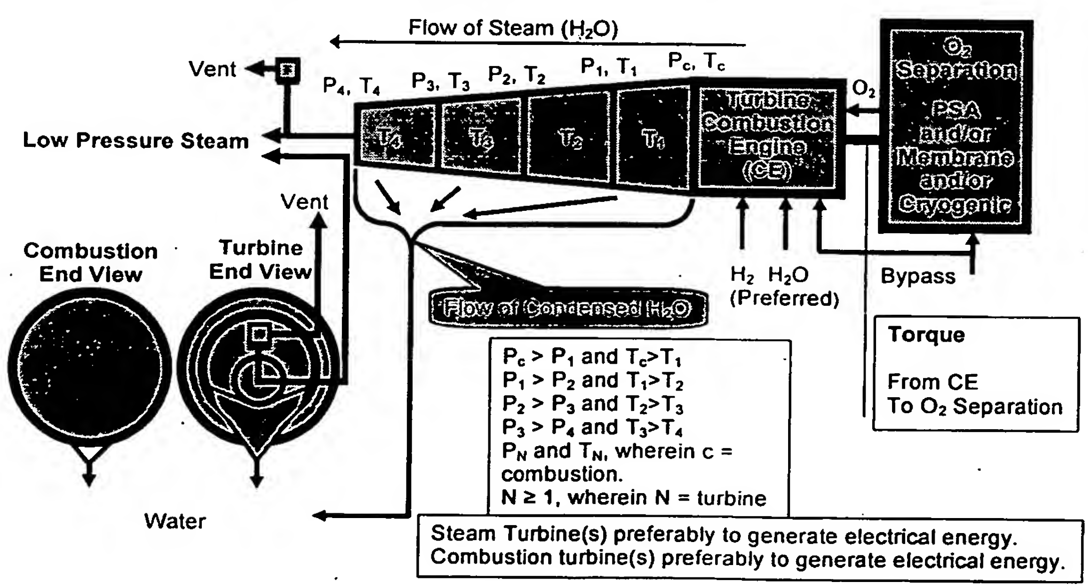
In contrast, ClearValue's Water Combustion Technology (WCT) minimizes energy losses utilizing the same laws of thermodynamics as an asset rather than incurring them as a liability. WCT increases the efficiency of the internal combustion engine to near 50 to 70% and that of power generation facilities to approximately 50-80%. In scientific terms, the new WCT improves combustion efficiency by minimizing: enthalpy, entropy and torque losses by turning otherwise lost energy into stored potential energy or fuel.

### ICE - Energy & Material Flow Diagram




In **ICE**: under normal operation, the WCT engine is insulated having no cooling loop managing combustion or block temperature during normal operation; temperature is managed with the addition of $H_2O$ to a mixture of pure $H_2$ and $O_2$ in the combustion chamber. Exhaust energy is converted to electrical energy via steam turbine(s); said electricity converts steam turbine condensate back into $H_2$ and $O_2$ via electrolysis.

### Combustion/Steam Turbine Configuration - Electrical Generation



In **electricity generation**, the WCT is insulated having no cooling loop during normal operation; temperature is managed with the addition of $H_2O$ to a mixture of pure $H_2$ and $O_2$. Exhaust energy, steam, is directly converted to electrical energy via steam turbine(s). The WCT Power Plant requires no: emission control units, boilers, heat exchangers or cooling towers; the WCT Power Plant is about 1/3 to ½ the footprint and the investment of a hydrocarbon facility. In both of these cases, **ICE** and **electricity generation**, $O_2$ is obtained from the air via separation of the air by: membranes, pressure swing adsorption, vacuum swing adsorption, or cryogenic distillation. In the case of **ICE**, cryogenic distillation most preferred, as the available $N_2$ heat sink solves the $H_2$ storage challenge by storing $H_2$ below its Joule-Thompson Curve. Such cryogenic storage of $H_2$ presents an $H_2$ storage tank which is smaller than the gasoline or diesel or kerosene storage tanks used today while obtaining significantly increased transportation distances between refueling, e.g. 500 miles or more.

In **HVAC**, $H_2$ would be piped to a home or business in a manner similar to that of natural gas is piped today. In **HVAC**, the entire home or business would be heated, using the available combustion energy of $H_2$, or cooled using the available heat sink from cryogenic $N_2$. In **HVAC** one centralized WCT Unit would provide all climate and refrigeration requirements. This is while $N_2$ cools with near 400% of the cooling efficiency of freon, e.g. the Joule Thompson coefficient of $N_2$ is 4 X that of freon.

In **jet propulsion**, the 3X energy factor of $H_2$ compared to kerosene is managed by increasing the air compressor capacity near about 160%, thereby maintaining thrust and exhaust gas temperature at 1/3 the poundage of fuel, and thereby significantly increasing flight distance and load capacity.

For an automobile, it is reasonable to assume: 1) the average WCT ICE has a life of 200k miles, 2) the average internal combustion engine obtains 20 mpg of gasoline, 3) the average WW price of gasoline is near $3 per gallon, and 4) the average vehicle investment is near $20k. Therefore, the cost of operating an internal combustion engine for 200k miles is approximately $60k on the average, or $0.30 per engine-mile with a fuel economy of $0.15 per mile.

For a fuel cell powered automobile, it is reasonably conservative to assume: 1) the average fuel cell engine has a life of 100k miles, 2) the fuel cell engine obtains 10 miles per pound of hydrogen, 3) the market price of hydrogen will be $1.00 per pound, and 4) the average vehicle investment will eventually be near $45k. Therefore, the cost of operating a fuel cell engine for 100k miles is approximately $100k, or on the average, or $0.55 per engine-mile with a fuel economy of $0.10 per mile.

For ClearValue's WCT, it is reasonable to assume that: 1) the average combustion engine will have a life of 400k miles (no carbon to foul engine parts), 2) the WCT will average 20 miles per pound of hydrogen, 3) the market price of hydrogen will be $1.00 per pound, and 4) the average vehicle investment is near $25k. Therefore, the cost of operating a WCT engine for 300k miles is approximately $45k on the average, or $0.112 per engine-mile with a fuel economy of $0.05 per mile.

For an electric power plant, it is reasonable to assume: 1) natural gas turbine/steam turbine efficiency of 35%, 2) natural gas price of $6 per tcf, and 3) natural gas energy value of 212 kcal/mole = 13.25 kcal per lb. Therefore, the fuel cost of operating an electrical generating facility with natural gas is near $0.10 per kcal of energy.

For a WCT Power Plant, it is reasonable to assume: 1) operating efficiency of at least 60%, 2) a hydrogen price of $1.00 per lb., and 3) a hydrogen energy value of 68 kcal/mole= 34 kcal/lb. Therefore, the fuel cost of operating an electrical generating facility with WCT is near $0.10 per kcal of energy **with no pollution and about 1/3 of the capital investment**.

**WCT requires less capital and operates more economically, while minimizing $CO_X$, $NO_X$, $SO_X$, $O_3$ and acid in our air.**

## The Market

Automobile and truck production is one of the largest and most well established industries WW. In the US, there are approximately 15M new cars and trucks sold every year; WW that figure approaches 55M units per year. There are currently over 500M cars and trucks operating WW. Further, the production of electricity absence a source of flowing water or moving air is performed with either nuclear fission or the burning of fossil fuels; due to the cost and the risks associate with fission, the burning of fossil fuels is often preferred.

Prototyping and early stage commercialization of the WCT is to be completed with partners in: combustion science, steam turbine design and manufacture, jet engine design and manufacture, electrolysis, cryogenics and transmission design.
Commercialization of the WCT is to be completed with Joint Venture partners in: transportation (internal combustion engines), electrical generation (combustion-steam turbine systems), jet engine (aerospace) and HVAC (furnace) applications. Joint Venture partners are to be established in countries of the Patent Cooperation Treaty (PCT), such as: US, Canada, Europe, China, Brazil, Indonesia and India. Technological innovation, such as this, will require political, as well as business and financial support.

## Intellectual Property (Sustainable Competitive Advantage)

ClearValue has 2 PCT Patent Applications pending WW. PCT/US 03/11250, which has published under WO 03/087564, is pending in Canada, Mexico, Germany, Russia, China, S. Korea, Japan, India, Indonesia and Australia. PCT US 06/48057 is an improvement upon PCT/US03/11250 and is awaiting publication. An allowance has been obtained in Great Britain from PCT/US03/11250. A U.S. Pat. Application was filed from PCT/US03/11250, 10/790,316, which is pending and has published as 2005.0198958. WW Regional patent applications are planned for PCT/US06/48057. (IP can be viewed at uspto.gov and wipo.int)

## Commercialization Strategy (ClearValue is rather flexible on Investor exit; however, IPO is deemed the most beneficial stage)

There are five stages of development planned for the WCT: 1) Proof-of-Concept; 2) Prototyping; 3) Technology and Commercialization Partners; 4) Translation and Market Penetration; and 5) Royalties and continued R&D.

**Proof-of-Concept** – In stage 1, ClearValue plans to complete: a racing style go-cart, a jet propelled model airplane, a miniature, 10KW Power Plant, and a 1 ton HVAC Unit. Each prototype is envisioned to have a development cost of near $50,000. As

each is completed it is anticipated that further intellectual property will be developed wherein $50,000 is budgeted for each. Therefore, completion of a proof-of-concept in each application area, including intellectual property, is estimated at about $400,000. Alternatively, any one of the four planned proof-of-concept units is estimated at about $150,000.

**Prototyping** – In stage 2, ClearValue plans to complete WCT engine modification of a: 1) production automobile, along with a motorcycle, 2) 1 Mega Watt Power Plant, 3) a 5 Ton HVAC Unit, along with the associated refrigeration and freezing units, and 4) production jet engine, along with the associated fuel tank(s). The capital requirement for all four prototypes is $25M; or, $9M individually; budgeted costs for the prototyping stage, including intellectual property development, are:

**Prototype Development Financial Budget Plan (Estimated for each: ICE, Jet[@], Power and HVAC)**

| Resource ($ k's) | 1Q | 2Q | 3Q | 4Q | 5Q | Totals |
|---|---|---|---|---|---|---|
| Office and Facility Cost | 175.0 | 175.0 | 175.0 | 190.0 | 190.0 | 905.0 |
| COO & Mgmt. | 75.0 | 75.0 | 75.0 | 100.0 | 100.0 | 425.0 |
| Business Support Staff | 30.0 | 30.0 | 30.0 | 45.0 | 60.0 | 195.0 |
| Patent/Legal Expense | 10.0 | 20.0 | 40.0 | 80.0 | 100.0 | 250.0 |
| 4 Engineers | 180.0 | 180.0 | 180.0 | 180.0 | 180.0 | 900.0 |
| 5 Prototype Designers | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 500.0 |
| Consulting fees | 75.0 | 75.0 | 150.0 | 150.0 | 150.0 | 600.0 |
| Technical Support Staff | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 1,500.0 |
| Facility Support Staff | 30.0 | 30.0 | 30.0 | 45.0 | 65.0 | 200.0 |
| Laboratory Equipment | 400.0 | 300.0 | 200.0 | 150.0 | 150.0 | 1,200.0 |
| Tooling/Equipment | 600.0 | 400.0 | 300.0 | 200.0 | 100.0 | 1,600.0 |
| Travel/Entertainment | 75.0 | 75.0 | 100.0 | 150.0 | 200.0 | 600.0 |
| Misc. | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | 125.0 |
| **Totals** | **2,075.0** | **1,785.0** | **1,705.0** | **1,715.0** | **1,720.0** | **9,000.0** |

[@] Given regulatory requirements, a full jet engine FAA program may be well in excess of $100M.

**Technology Validation and Commercialization Partners (IPO Stage)**

1. Identify Required Development/Commercialization Partners,
2. Contract Potential Future Intellectual Property Ownership,
3. Complete Commercialization/Business Development in Four Industries:
   - Transportation having a Licensing Fee of $200 M,
   - Electrical Generation, Power/Steam Turbine, having a Licensing Fee of $100 M,
   - Jet Propulsion, having a Licensing Fee of $50 M, land
   - HVAC, having a Licensing Fee of 25 M.

**Translation/Market Penetration**

**Licensing Fees:**
- $500 M for Transportation (10 + planned),
- $500 M for Power/Steam Turbine Equipment (10 + planned),
- $100 M for Jet Propulsion (10 + planned), and
- $ 50 M for HVAC (20 + planned).

**Royalties (Estimated):**
1. Transportation - $500 per engine and $500 per vehicle,
2. Electrical Generation - $0.50 per KWH generation capacity and $0.020 per KWH of electricity.
3. Jet Propulsion - $10,000 to $250,000 per Engine and $10,000 to $10 M per airplane,
4. HVAC - $100 per ton/$10 per burner.

**Success Requirements:**
- World class technology/business development,
- Political support within each commercialization county,
- Flow forward and flow back technology agreements within licensing agreements,
- Translation across entire market application opportunities, and
- Continued world class R&D.

**This is a socially responsible technology and business. This is a technology which will not only prove beneficial to all of humankind, but also has the capability of providing very significant financial returns.**

**The WCT is a ClearValue.**

CV ClearValue®

clearvalue.com

The Earth is mostly water.
Our bodies are mostly water.
ClearValue's Innovations improve
our water, our air, our health and our world.

# ClearValue's WCT – Including the Haase Cycle

The combustion of fossil fuels is the combustion of HYDRO-carbons. ClearValue's Water Combustion Technology is the combustion of HYDRO-gen. The processes are chemically very similar.

| | | |
|---|---|---|
| $C_nH_{2n+2} + (2n+1)O_2$ | $\longrightarrow$ | $nCO_2 + (n+1)H_2O$ + energy |
| gasoline + 12.5 $O_2$ | $\longrightarrow$ | $8CO_2 + 9H_2O$ + 1,300 kcal |
| nat. gas ($CH_4$) + $2O_2$ | $\longrightarrow$ | $CO_2 + 2H_2O$ + 213 kcal |

**Combustion of HYDRO-carbons**

$2H_2 + O_2 \longrightarrow 2H_2O$ + energy
$2H_2 + O_2 \longrightarrow 2H_2O$ + 137 kcal
$H_2$ has 3X the energy per pound

**Combustion of HYDRO-gen**

In both cases, Oxygen ($O_2$) is the oxidant and Water ($H_2O$) is the combustion product. In hydrocarbon combustion, however, carbon does also combust to carbon dioxide ($CO_2$), a greenhouse gas. (During incomplete combustion, carbon does also combust to carbon monoxide (CO), a poisonous gas:) Unfortunately, to complicate matters, hydrocarbon combustion is performed with air instead of ($O_2$); this is while air is only about 20% $O_2$, being 80% nitrogen ($N_2$). A portion of the $N_2$ in air combusts endothermically (adsorbing energy) to produce oxides of nitrogen, $NO_X$ (NO, $NO_2$ and $NO_3$). While $NO_X$ is toxic to all life, $NO_X$ also catalyzes the conversion of $O_2$ to ozone ($O_3$). $NO_X$ and $O_3$ inhibit nature's ability to complete photosynthesis (Photosynthesis is the biochemical pathway utilized by plant life to convert $CO_2$ back into $O_2$). Further, $O_3$ is toxic at the Earth's surface, yet naturally produced from $O_2$ in the upper atmosphere to protect all life from UV radiation. Therefore, air pollution ($CO_X$ and $NO_X$) not only places greenhouse and poisonous gases in our air, air pollution also reduces nature's ability to replenish our air, e.g. O2. Further, oil which is the raw material for: gasoline, diesel and kerosene, has sulfur as a natural contaminant. Sulfur combusts to form $SO_X$ ($SO_2$, $SO_3$ and $SO_4$). $NO_X$, $SO_X$ and $CO_X$ form acids with water, thereby creating acid rain. In conclusion, simply removing C, N and S from combustion removes $CO_X$, $NO_X$ and $SO_X$, acids and $O_3$ from our air.

**A Most Significant Challenge to Humanity**

While humanity has been rather creative in the use of fossil fuel to provide energy, it is without question that said use will lead to environmental consequences; while, those consequences may be of biblical proportions. As the Earth warms, due to the release of COX and NOX into the Earth's atmosphere, the Earth adapts to the warmth, increased energy, which exists in Earth's oceans and in Earth's atmosphere. That adaptation is causing changes in weather patterns, including record hurricane and tornado events, along with flooding and drought, depending upon location. Drought causes wildfires, while the flooding causes destruction of personal property. And, these events are seen with only a 1 ° C increase in the average Earth temperature. Should humanity not change in the use of fossil fuel to provide energy, computer models predict a 5 to 7 ° C increase in the average Earth temperature within the next 50 to 100 years. Only a 3 to 5 ° C increase in the average Earth temperature is required to melt Earth's glaciers and polar ice caps. Such a melting and thereby dilution of the salt content within Earth's oceans is predicted to stop the "warm water conveyance systems" in Earth's oceans. Should such a terrible event take place, we should bear in mind the significant heat sink which exists just outside our atmosphere, Space, wherein the temperature is only 1 to 3 K, e.g. – 450 to – 460 ° F. Having such an immense capacity to adsorb energy so close to home, it is not hard to imagine that if the extreme northern and southern portions of the Earth are not heated with the warm waters of the tropics that those extreme northern and southern portions of the Earth will cover with ice. Should humanity cause the next ice age, humanity will have caused their own calamity. And, should the "ice age scenario" not come to pass, that same melting of the glaciers and the polar ice caps will raise Earth's oceans by over 50 feet; such a rise in Earth's oceans would place many coastal cities under water while being a calamity of biblical proportions in its own right. The worst case scenario is a rising of the oceans followed by an ice age; in this scenario, humanity would leave the oceans for the higher altitudes. Once located in the higher altitudes, an ice age would be horrific.

**For our children, we must take action! We must replace fossil fuel energy sources! We must preserve our home!**

The WCT Haase Cycle presents combustion of hydrogen with oxygen producing $H_2O$ as the combustion product, wherein management of energy and of combustion is significantly improved. The WCT Haase Cycle presents improved thermodynamics, thereby improving combustion power and efficiency, 2 – 10X and 50-70%, respectively. The WCT Haase Cycle utilizes steam from combustion to: 1) maintain power output of combustion, 2) provide method(s) of energy storage and transfer, 3) provide method(s) of energy recycle, 4) provide power, and 5) cool the combustion chamber. Steam is a potential energy source, both from kinetic and available heat energy, as well as conversion to $H_2$ and $O_2$.

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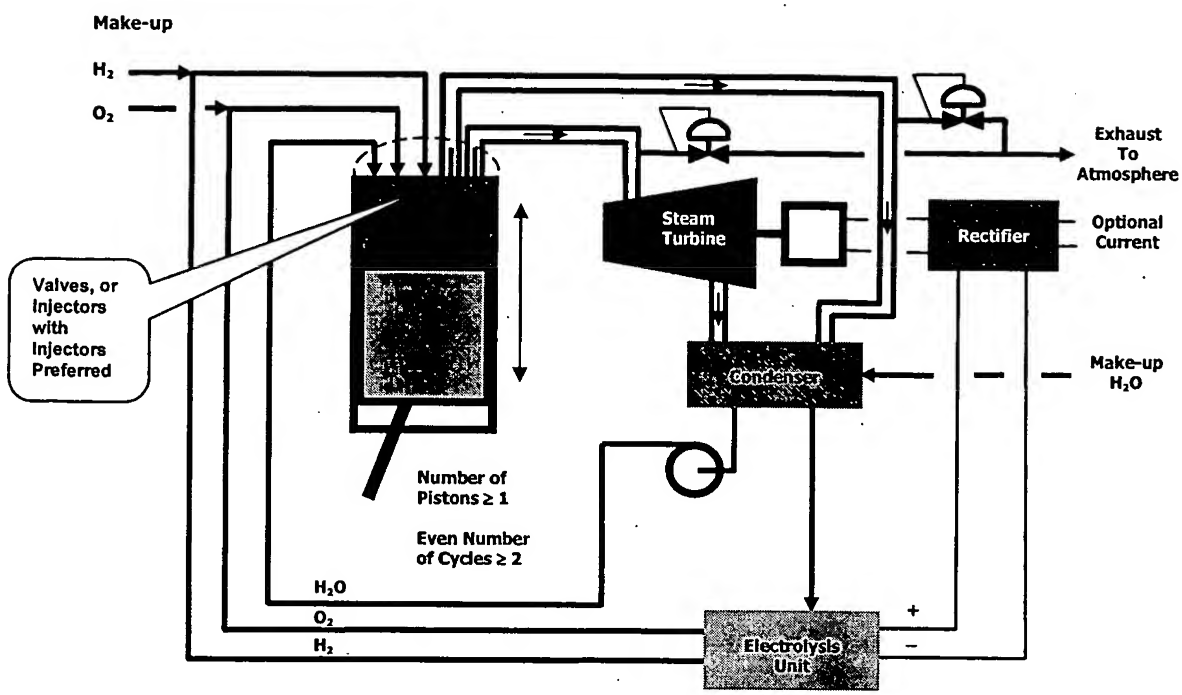
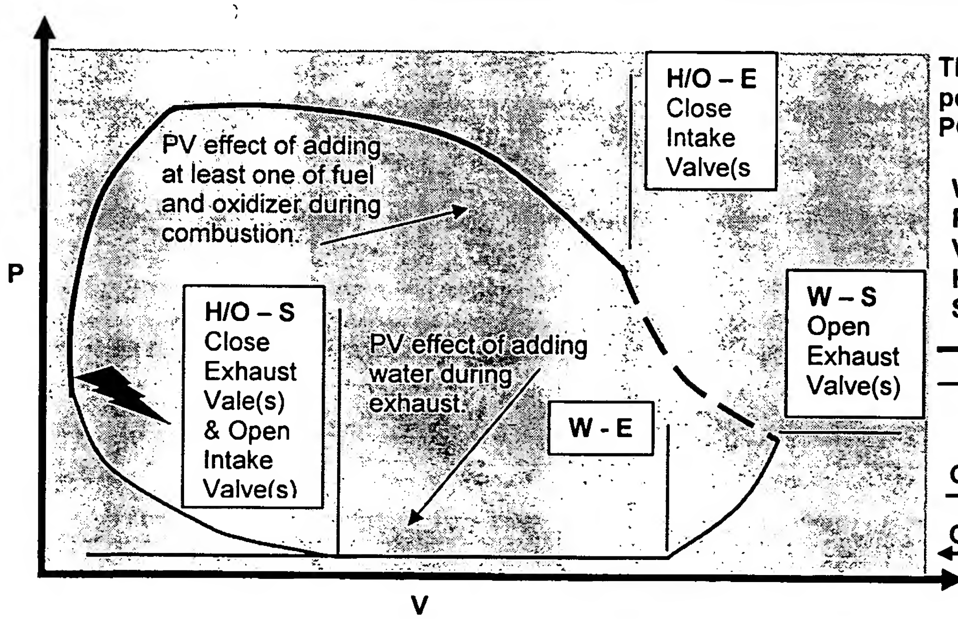



The above depicts The Haase Cycle, wherein water is used during at least one of a combustion cycle and a cooling cycle, e.g. water is added to the combustion chamber or cylinder to adsorb heat energy and to create steam. Said steam then provides pressure within the combustion chamber to create work (in the case of a piston, work = Δpressure x Δvolume). Excess steam energy, assuming that there is not enough water cycle(s) to adsorb all of the available excess heat energy, is them converted back into fuel by converting said excess steam energy into electricity and then converting the resultant steam condensate back into fuel and oxidizer, e.g. $H_2$ and $O_2$, via at least a portion of said electricity generated by said steam turbine.

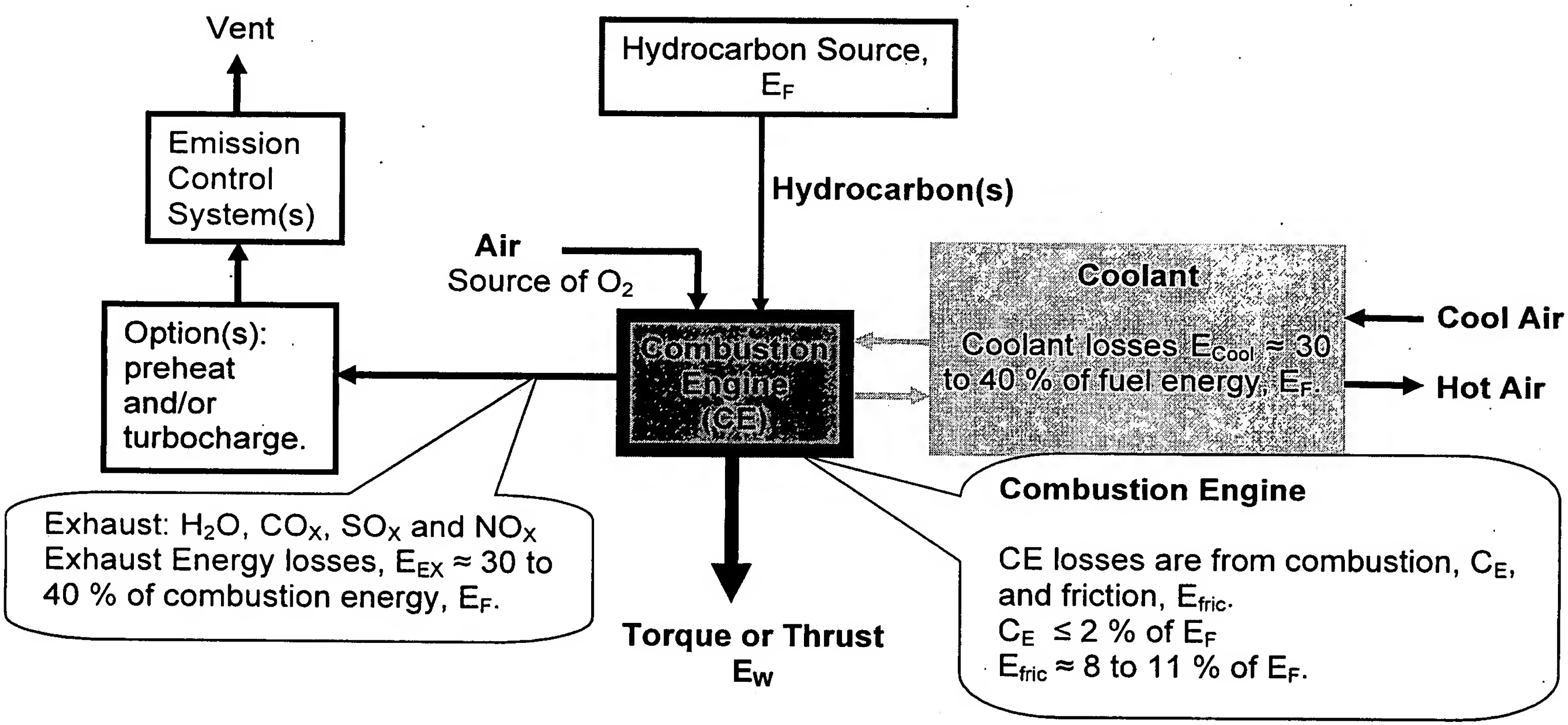



**The Haase Cycle is patent pending world wide according to PCT/US06/048057.**

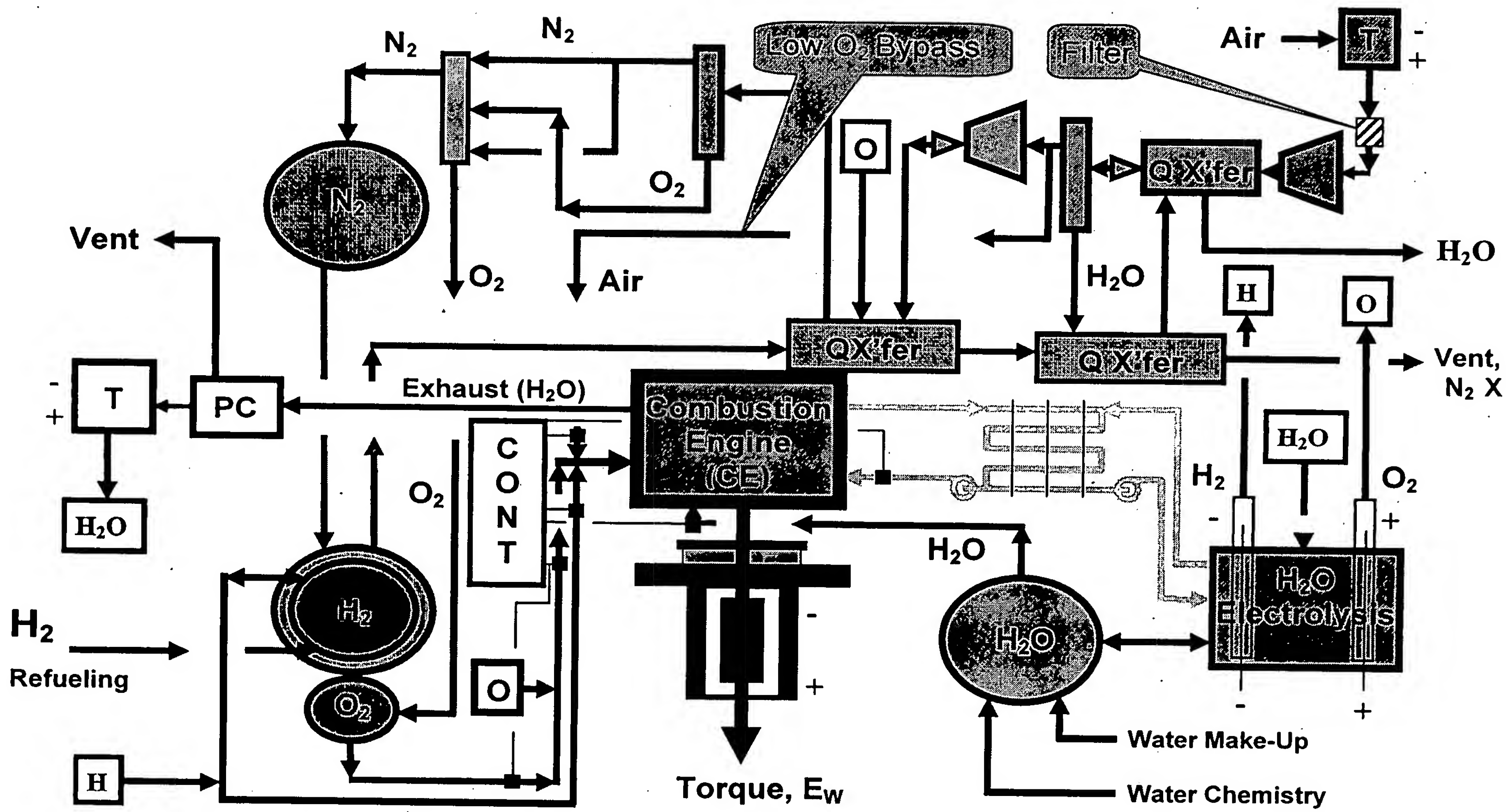
**Work = Δ Pressure X Δ Volume**
**P = Pressure**
**V = Volume**
**H/O = Addition of $H_2$ and/or $O_2$**
**S, E = Start, End**
**Combustion/Power**
**Intake/Exhaust**
**Spark, if desired**
**Chamber (Volume) Expansion**
**Chamber (Volume) Contraction**

As the work performed by a combustion engine equals the change in pressure times the change in volume in a combustion chamber, e.g. cylinder, The Haase Cycle improves engine power by altering the previously known Otto Cycle. The Haase Cycle is able to improve said engine power by expanding the Otto Cycle PV envelope. Said expansion is performed by adding water during either the combustion cycle or during a separate cooling cycle wherein combustion is not performed. Said water addition is performed such that the temperature and thereby the pressure of the combustion chamber is reduced, as graphically shown above. During the combustion cycle, at least one of fuel and oxidizer are added to the combustion chamber so as to expand the PV envelope as graphically shown above. A slow burn is preferred. Due to the auto-ignition temperature of $H_2$ and $O_2$, the spark, depicted above, is not required.

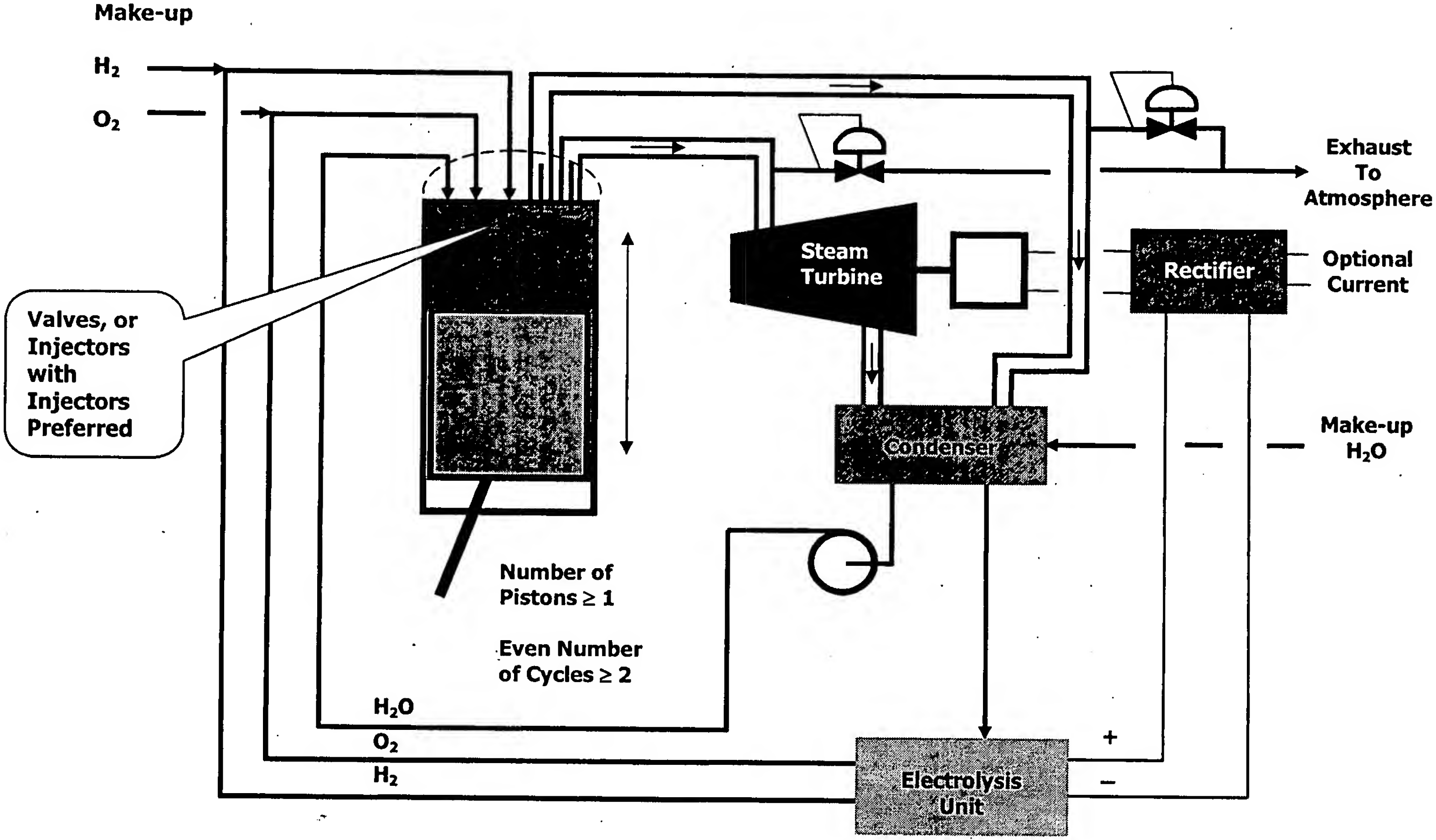
## Traditional Combustion - Hydrocarbon(s) & Air



# ICE - Energy & Material Flow Diagram

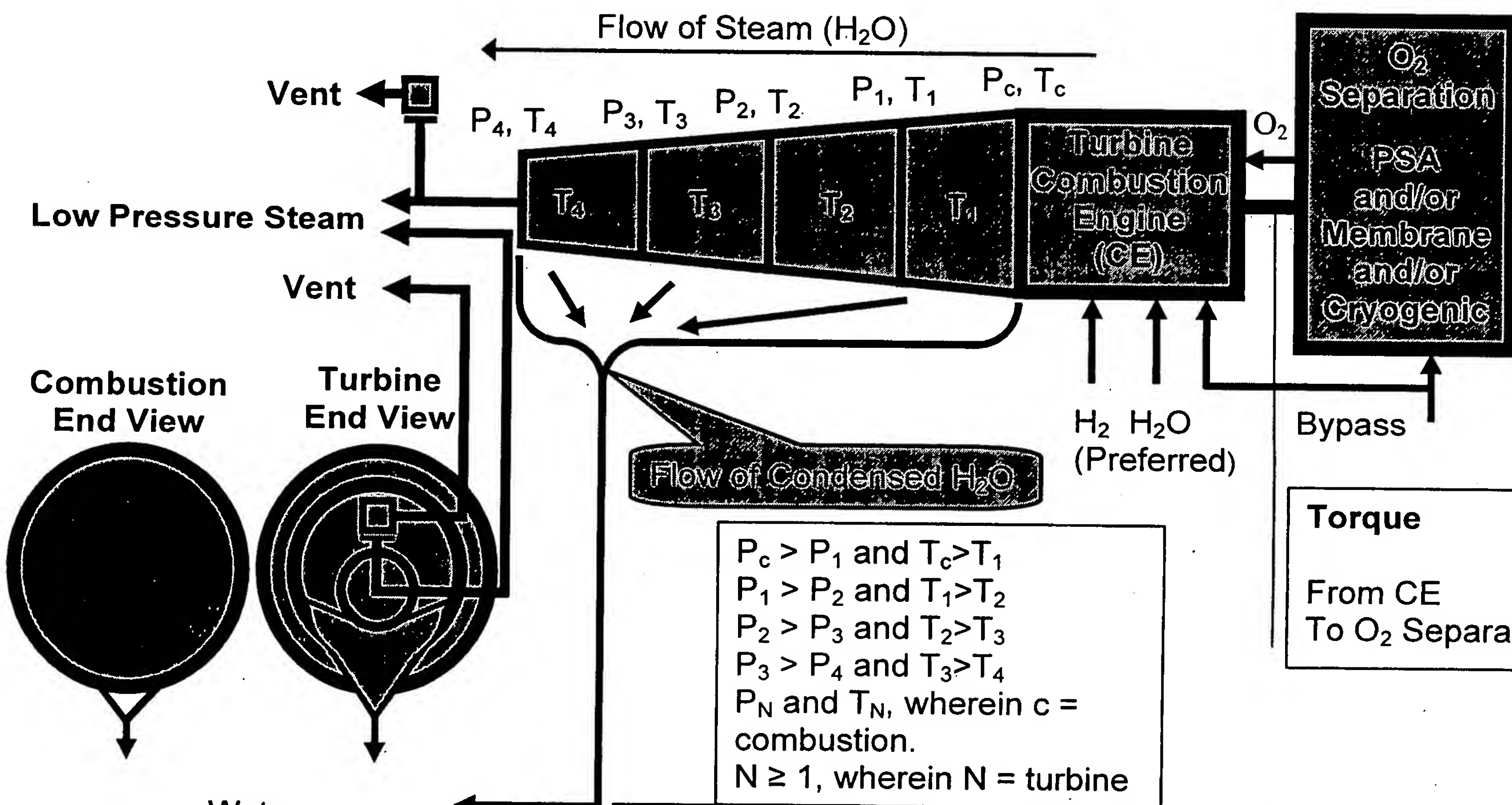


# ClearValue's ICE Incorporating "The Haase Cycle"




Spark Ignition is Optional

# Combustion/Steam Turbine Configuration Electrical Generation




$P_c > P_1$ and $T_c > T_1$
$P_1 > P_2$ and $T_1 > T_2$
$P_2 > P_3$ and $T_2 > T_3$
$P_3 > P_4$ and $T_3 > T_4$
$P_N$ and $T_N$, wherein c = combustion.
$N \geq 1$, wherein N = turbine

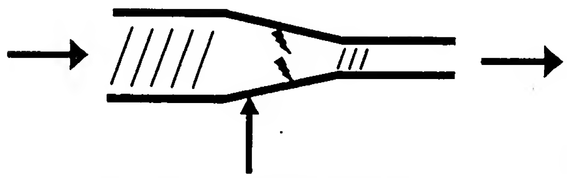
**Torque**

From CE
To $O_2$ Separation

Steam Turbine(s) preferably to generate electrical energy.
Combustion turbine(s) preferably to generate electrical energy.

# ClearValue's WCT - Jet Propulsion

**(Air) dMo/dt Vo**



**(Thrust) dMe/dt Ve**

**Fuel, F ($H_2$ or Kerosene)**

***(Jet Propulsion is a Momentum Balance)***
**Ve >> Vo**

Thrust = dMe/dt Ve – dMo/dt Vo, Let Me = Mo + $M_F$, $M_F$ = mass of fuel.

$F = {}_{to}\int^{t1} {}_{Vo}\int^{Ve} Me - Mo = {}_{to}\int^{t1} {}_{Vo}\int^{Ve} Mo + M_F - Mo = {}_{to}\int^{t1} {}_{Vo}\int^{Ve} M_F$

$F_{WCT} = {}_{to}\int^{t1} {}_{Vo}\int^{Ve} \{M_{H2} + M_{O2} + M_{H2O} + M_{AIR}\}$, for Kerosene $F = {}_{to}\int^{t1} {}_{Vo}\int^{Ve} \{M_{FK} + M_{AIR}\}$

Is, $F_{WCT} \geq F_K$ ?; $\therefore$ is, $\{M_{H2} + M_{O2} + M_{H2O}\} \geq \{M_K\}$ ?
And, if air is used instead of $O_2$, then is $\{M_{H2} + M_{H2O} + M_{Air}\} \geq \{M_K + M_{AIR}\}$ ?

$\Delta H_{H2}$ = 51,571 BTU/lb., $\Delta H_K$ = 19,314 BTU/lb.,

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$
lb.+ 8 lb. $\rightarrow$ 9 lb.

$C_{14}H_{30} + 43/2\ O_2 \rightarrow 14\ CO_2 + 15\ H_2O$
1 lb. + 3.47 lb. $\rightarrow$ 3.11 lb. + 1.36 lb.

$Cp_K$ = 0.6 BTU °F/lb., $Cp_{H2O} \approx$ 0.46 BTU °F/lb., $Cp_{H2}$ = 3.45 BTU °F/lb., $Cp_{AIR}$ = 0.46 BTU °F/lb.,
$\Delta H_{V,H2O}$ = 974 BTU/lb., $\Delta H_{F,H2O}$ = 144 BTU/lb., Kerosene(K) a liquid, $H_2$ vaporizes @ STP

**ΔH Combustion = Σ ΔH's**

$\Delta H_K = Cp_K$ (lb. K)(1000) + $Cp_{AIR}$ (3.47/0.18)(1000) + $Cp_{AIR}$(lb. AIR)(1000)
19,314 = (0.6)(1)(1000) + 0.46(3.47/0.18)(1000) + 0.46(lb. Air)(1000) .

$\therefore$ **For Kerosene, 1 lb. K/40.3 lb. air = 41.3 lb. thrust @ 1000°F.**

$\Delta H_{H2}$ = 3.45(1)(1000) + 0.46(8/0.18)(1000) + 0.46(lb. $H_2O$)(1000) + 974(lb. $H_2O$)
51,571 = 3450 + 20,444 + 1434(lb. $H_2O$), $H_2O$ cooling = 19.3 lb., Air = 8/0.18 = 44.4 lb.

$\therefore$ **lb. $H_2$/44.4 lb. air/19.3 lb. $H_2O$ = 64.7 lb. thrust. (Requires 10% air increase @ 1000°F).**

$\therefore$ **$H_2$ w/air cooling, 0.37 lb. $H_2$/39.22 lb. Air = 39.6 lb. Thrust**

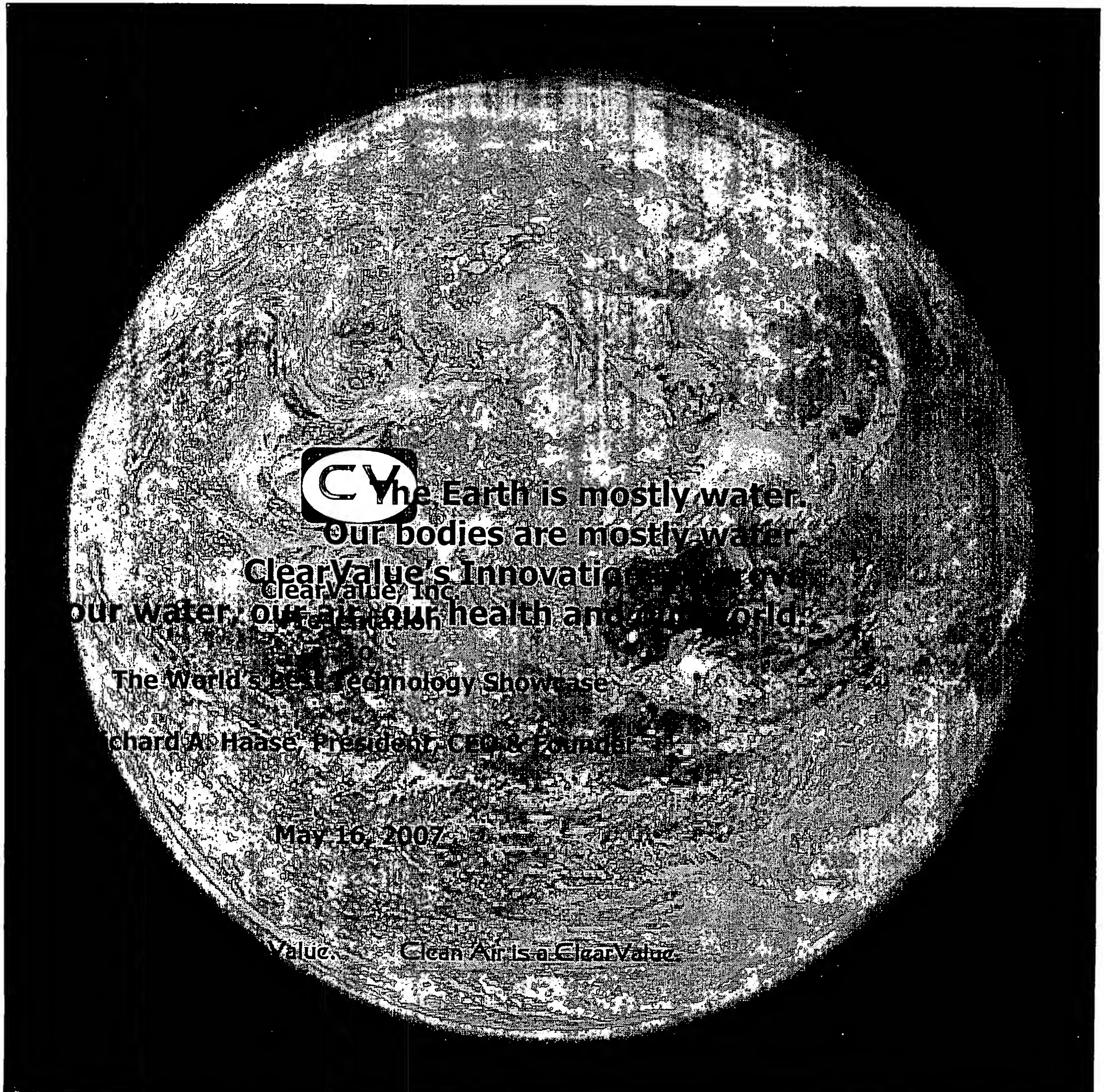
$\therefore$ **Lb. thrust/lb. fuel: $H_2$/Air = 39.6; Kerosene/Air = 41.3; $H_2$/$H_2O$ = 3.18**

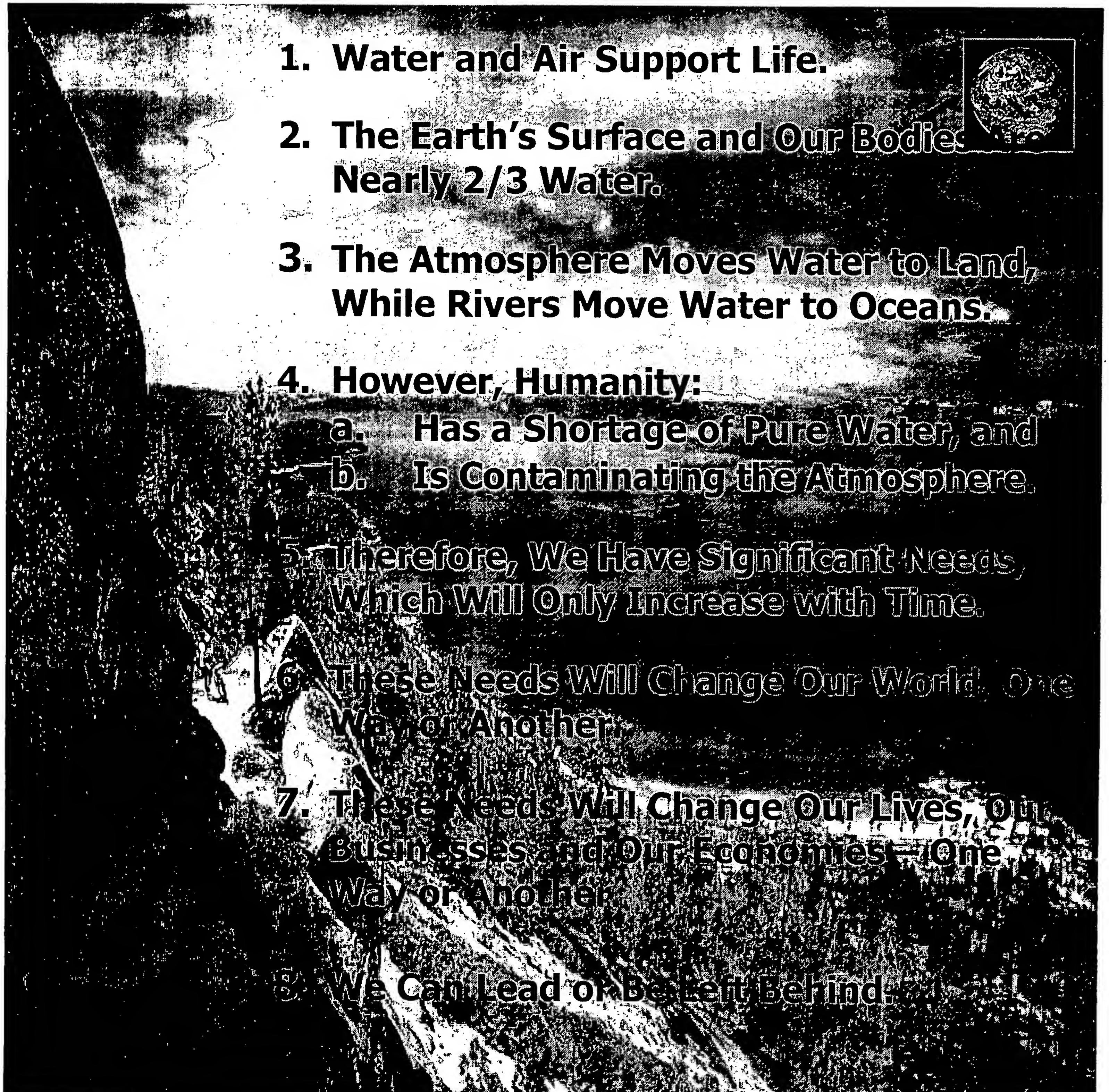
$\therefore$ ***Previous $H_2$ issues now obvious; $H_2$ w/air requires 30% more air.***

$\therefore$ **$H_2$/air Engines Require Increased Air Compression to Balance Thermodynamics, e.g. about 160% more air.**

$\therefore$ **Liquid $O_2$ and $H_2O$ supplement combustion at high altitudes, and**

$\therefore$ **$H_2O$ & $H_2O$/Air JtC Can Cool Exhaust Reducing Heat Trail.**


The Earth is mostly water.
Our bodies are mostly water.
ClearValue's Innovations
our water, our air, our health and our world.
ClearValue, Inc
The World's Best Technology Showcase
chard A. Haase, President, CEO & Founder
May 16, 2007
Value.
Clean Air is a ClearValue.


1. Water and Air Support Life.
2. The Earth's Surface and Our Bodies
Nearly 2/3 Water.
3. The Atmosphere Moves Water to Land,
While Rivers Move Water to Oceans.
4. However, Humanity:
a. Has a Shortage of Pure Water, and
b. Is Contaminating the Atmosphere.
5. Therefore, We Have Significant Needs,
Which Will Only Increase with Time.
6. These Needs Will Change Our World, One
Way or Another.
7. These Needs Will Change Our Lives, Ou
Businesses and Our Economies – One
Way or Another.
8. We Can Lead or Be Left Behind.

# Vision and Mission

## Vision

Water purification and hydrogen technologies will be more important to humanity than any other resource technology by 2010. Hydrogen will begin to replace hydrocarbons by 2010.

## Mission

ClearValue is to become a technology leader in the drinking water and the wastewater treatment industry by the year 2001. (Done)

ClearValue is to become a preferred supplier of municipal & industrial water chemicals and bio-chemicals by the year 2010.

ClearValue is to become the technology leader in hydrogen combustion by 2005. (Done)

ClearValue is to be recognized as the leading supplier of hydrogen combustion technologies by 2010.

## Innovation

ClearValue is a technology focused company. ClearValue strives to bring forth innovative chemical, bio-chemical and thermodynamic technologies to industries which have primarily seen innovation in equipment. As such, ClearValue's technologies reduce investment while significantly improving operating cost.

# Intellectual Property Position

| Title | Allowed or US Pending | PCT |
|---|---|---|
| **ClearValue/CV Trademarks** | 2,092,823<br>275432 | N/A |
| Clarification of Water & Wastewater | 6,120,690<br>10/413,849<br>20030209499 | US99/18338<br>00/09453 |
| Bio-Filtration of Water and Wastewater | 10/117,682 | US01/10426<br>WO 01/74725<br>US01/41884 |
| POE Device | 09/918,246 | US00/10657 |
| ACH/D Manufacture | US02/023651<br>WO 03/009811<br>11/041,329 | US02/023651<br>WO 03/009811<br>11/041,329 |
| $H_2O_2$ Manufacture | 10/602,742 | None |
| Dewatering Thermophilic Bio-Solids<br>Re-Issues Expected 2005 | 5,846,435 RX/RI<br>5,906,750 RI | N/A |
| Process of Bio-treating Wastewater (Biological Sulfide Odor Control) | 6,136,193 | N/A |
| Biotreatment of Wastewater<br>(Nitrification in Sulfide Laden Water) | 5,705,072 | N/A |
| Bio-Solids Recycling (Biological Removal of Pathogens, Ammonia and Sulfides) | 11/068,101 | US02/27772<br>WO 03/05554 |
| Recycling Waste Metals into Coagulants | 10/969,393 | N/A |
| Hydrogen Combustion -<br>Thermodynamic Redesign of Combustion w/$H_2$ & Pure $O_2$ Utilizing Cryogenics | BP 2407372<br>10/790,316 | US02/11250<br>WO 03/087564<br>US03/041719<br>WO 04/074656 |

**ClearValue, Inc.**
**(Founding Organization)**

Municipal & Industrial
(Water Purification)

Residential & Commercial
(Water Purification)

Water Chemical
Manufacturing
(ACH/Disinfectants/$H_2O_2$)

Nutrients
(Bio-Solids Recycling)

Combustion
(Hydrogen Combustion Technology)

Technologies
(LLC for Intellectual Property)

CV ClearValue®

# Air Purity Issues

**Hydrocarbon Combustion**

- Affects the Earth, Fouling the Air Globally.
- Affects Health, Business, Economics and Politics Globally.

**Carbon Oxides ($CO_X$) – Monoxide (CO), Dioxide ($CO_2$) and Carbonate ($CO_3$)**

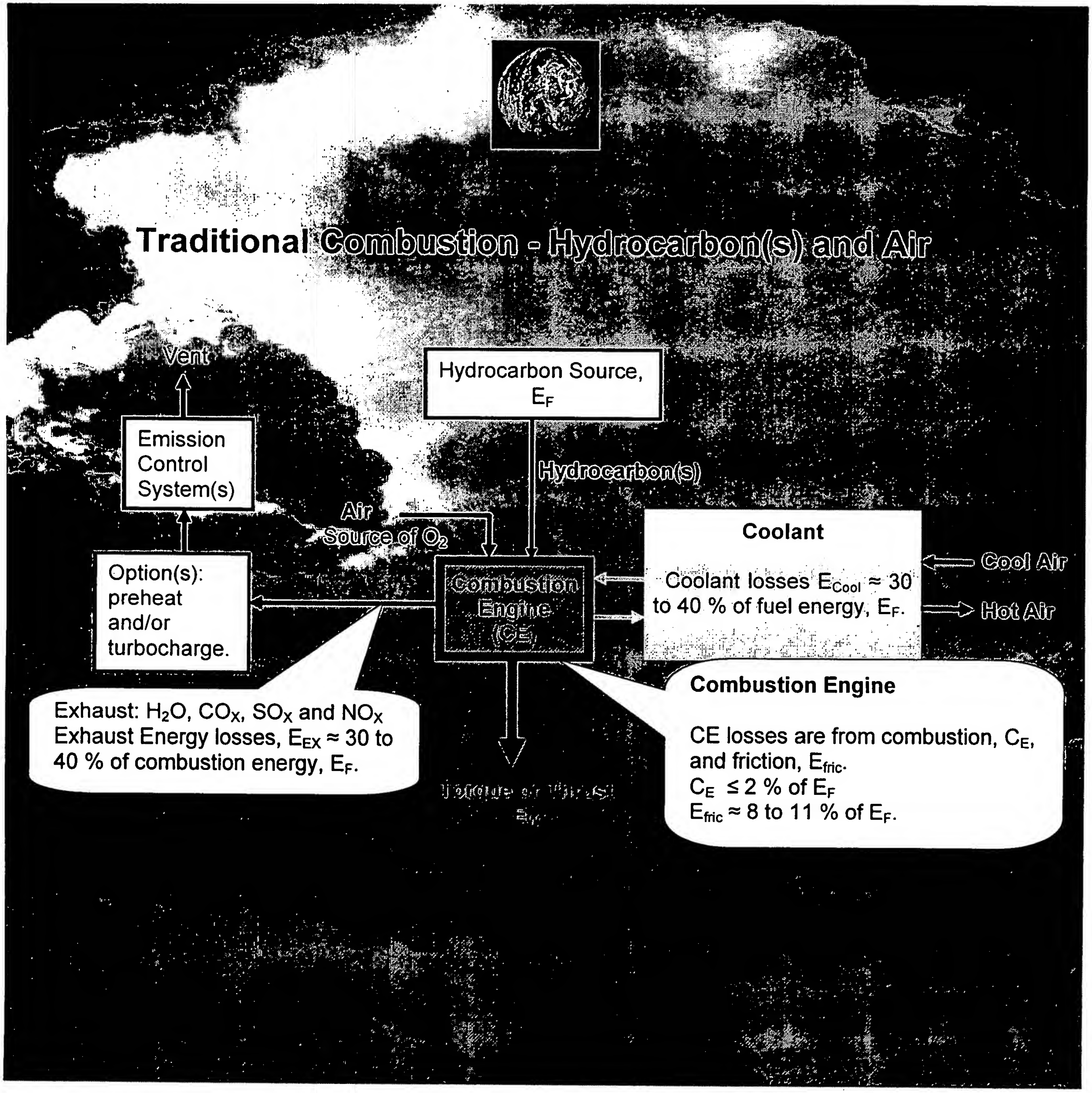
- $CO_X$ Produced by Hydrocarbon Combustion,
- CO is a Poisonous Gas,
- $CO_2$ is a Natural Gas Converted to $O_2$ By Photosynthesis,
- $CO_2$ and $CO_3$ Form an Acid with Humidity,
- $CO_2$ Production Surpassed Earth's Ability to Convert,
- Excess $CO_2$ Produces Global Warming,
- Global Warming Affects The Environment and The Economy.

**Nitrogen Oxides ($NO_X$) – Monoxide (NO), Dioxide ($NO_2$) and Nitrate (NO3)**

- $NO_X$ Produced During Combustion with Air,
- $NO_X$ Inhibits Photosynthesis, Worsening Global Warming,
- $NO_X$ Catalyzes the Formation of Ozone ($O_3$),
- NO is a Poisonous Gas Forming Acid with Humidity,
- $NO_2$ and $NO_3$ Form an Acid with Humidity.

**Sulfur Oxides ($SO_X$) – Dioxide ($SO_2$), Sulfite ($SO_3$) and Sulfate ($SO_4$)**

- $SO_X$ Produced During Combustion of Oil and Oil Byproducts,
- $SO_2$ an Objectionable Poisonous Gas "Rotten Egg Smell,"
- $SO_3$ and $SO_4$ Form an Acid with Humidity.


Traditional Combustion - Hydrocarbon(s) and Air
Vent
Emission Control System(s)
Hydrocarbon Source, $E_F$
Hydrocarbon(s)
Air Source of $O_2$
Option(s): preheat and/or turbocharge.
Combustion Engine (CE)
Coolant
Coolant losses $E_{Cool} \approx 30$ to 40 % of fuel energy, $E_F$.
Cool Air
Hot Air
Exhaust: $H_2O$, $CO_X$, $SO_X$ and $NO_X$
Exhaust Energy losses, $E_{EX} \approx 30$ to 40 % of combustion energy, $E_F$.
Combustion Engine
CE losses are from combustion, $C_E$, and friction, $E_{fric}$.
$C_E \leq 2$ % of $E_F$
$E_{fric} \approx 8$ to 11 % of $E_F$.

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# Water Combustion Technology (WCT) Is The Answer

## The Earth

- Is Mostly Water,
- Continuously Manages and Moves Large Quantities of Water,
- In Need of Clean Water, Therefore
- Clean Water Exhaust Works With, Rather Than Against, The Earth.

## ClearValue's Water Combustion Technology

- Burns Pure $H_2$ and Pure $O_2$ Producing Pure $H_2O$,
- Capital Cost 30 % Greater Than Hydrocarbon,
- 200 % Longer Engine Life Than Hydrocarbon,
- Internal Combustion Engines 60 % Efficient,
- Turbines 40 % Efficient, and
- 25 % Less Operating Cost than Hydrocarbon.

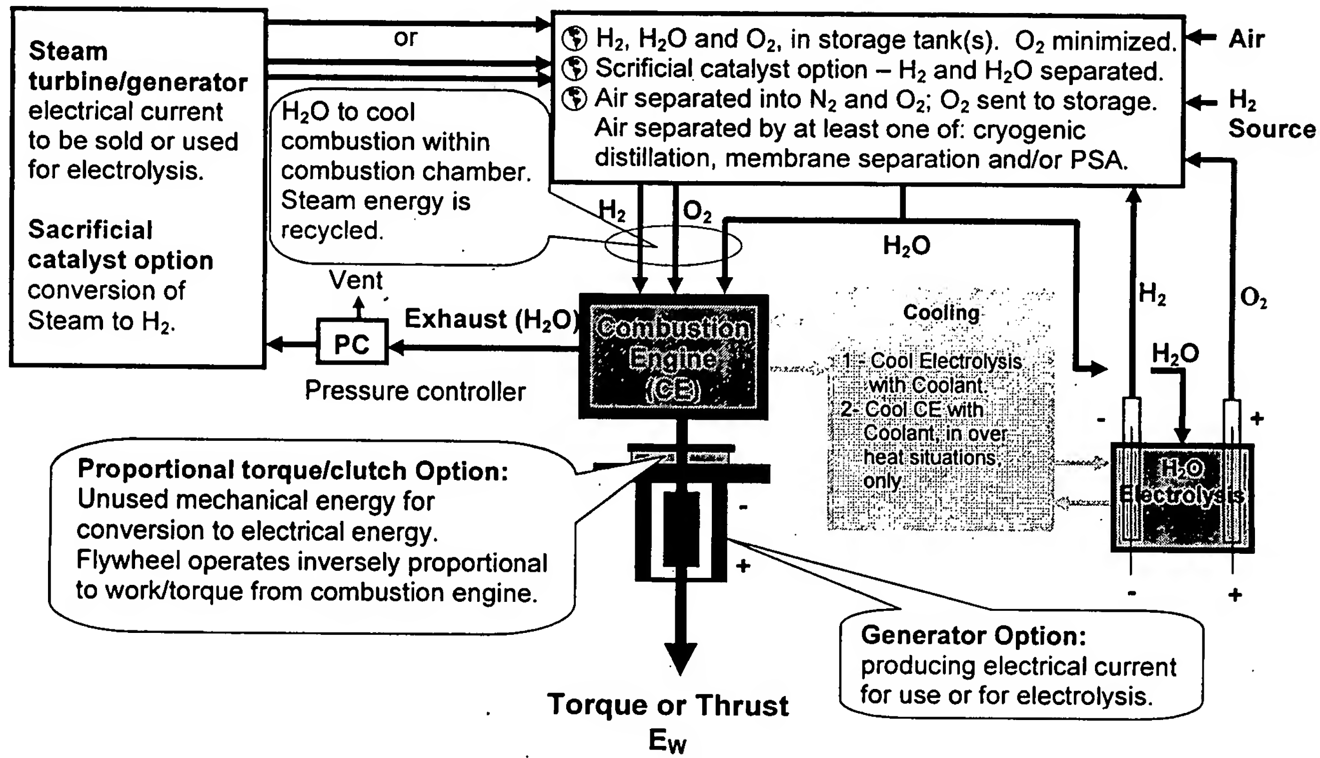
## Fuel Cells

- Earth Doesn't Have Enough Platinum For 1 Year's Automotive Production,
- Produce $NO_X$, (Air is Source of $O_2$),
- Do Not Have Expected Internal Combustion Engine "Feel,"
- Complex, Requiring Banks of Fuel Cells,
- Capital Cost 3 to 5 Times Hydrocarbon,
- 2 to 3 Times the Maintenance of Hydrocarbon,
- Fuel Efficiency Near 35%, and
- 30 to 50 % Greater Operating Cost Than Hydrocarbon.

## Traditional Combustion Systems Modified For Hydrogen ($H_2$)

- Burn Hot Requiring Expensive Metallurgy,
- $NO_X$ Produced During Combustion with Air,
- Produce More $NO_X$ Than Hydrocarbon (High Combustion Temperature),
- $NO_X$ Inhibits Photosynthesis and Catalyzes $O_3$ Formation,
- 20% Fuel Efficiency, and
- 50 to 100% Greater Operating Cost Than Hydrocarbon.

# ClearValue's Water Combustion Technology




$$2H_2 + O_2 \rightarrow 2H_2O + \text{energy}$$

$$2H_2 + O_2 \rightarrow 2H_2O + 137\ \text{kcal}$$

**$H_2$ has 3X the energy per pound compared to Hydrocarbons**

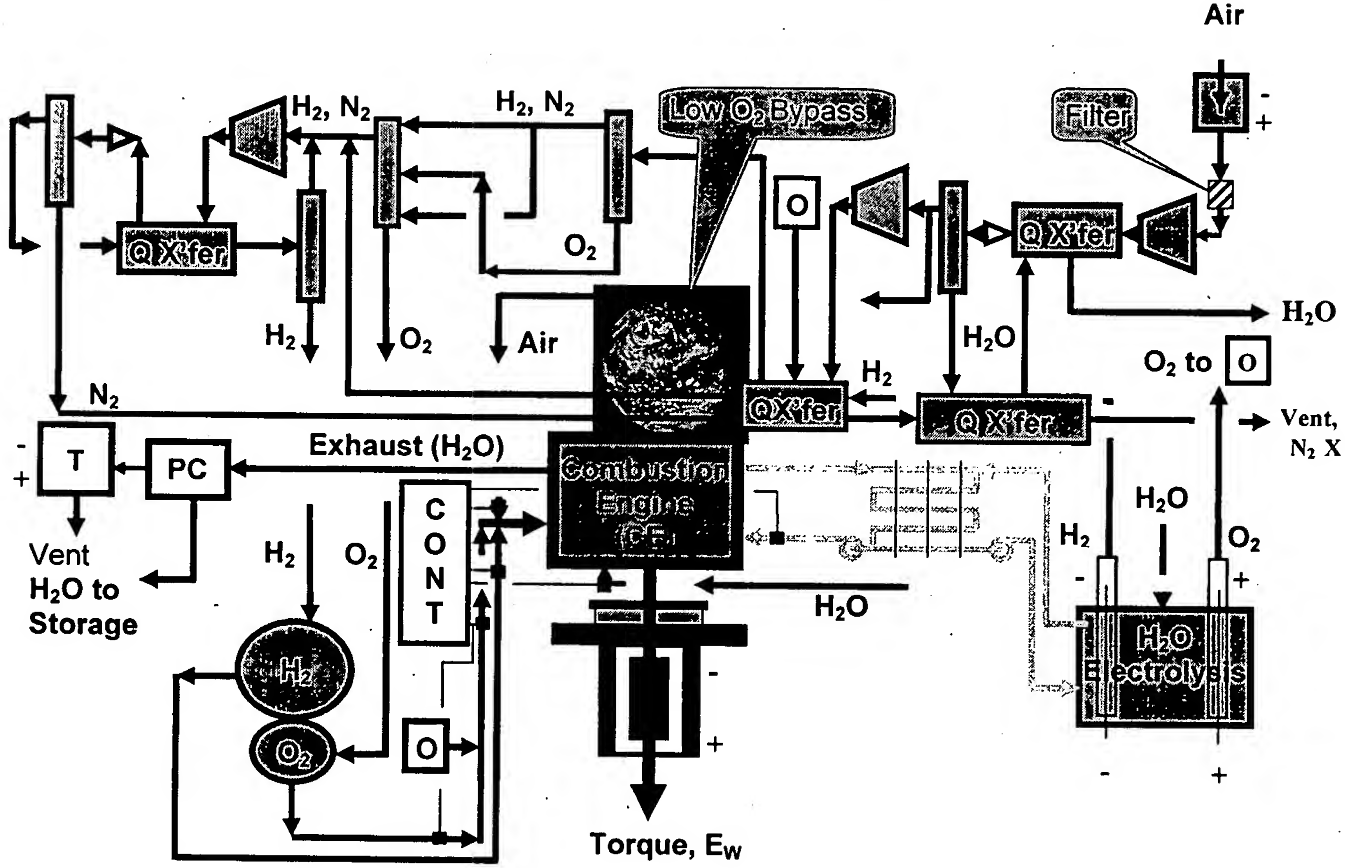
$$E_F = E_W + E_{EX} + E_{Cool} + E_{fric} + C_E$$

$$E_F = E_W + \approx 10\ \%\ E_F + \approx 10\ \%\ E_F + \approx 9\%\ E_F + \approx 1\%\ E_F$$

**$E_F = E_W + \approx 40\%\ E_F$ in energy losses for internal CE(s).**

**$E_F = E_W + \approx 60\%\ E_F$ in energy losses for Turbine CE(s).**

# ClearValue's Water Combustion Technology
# Most Preferred Internal Combustion Engine
# Energy & Material Flow Diagram




**Thermodynamic Redesign of Combustion**

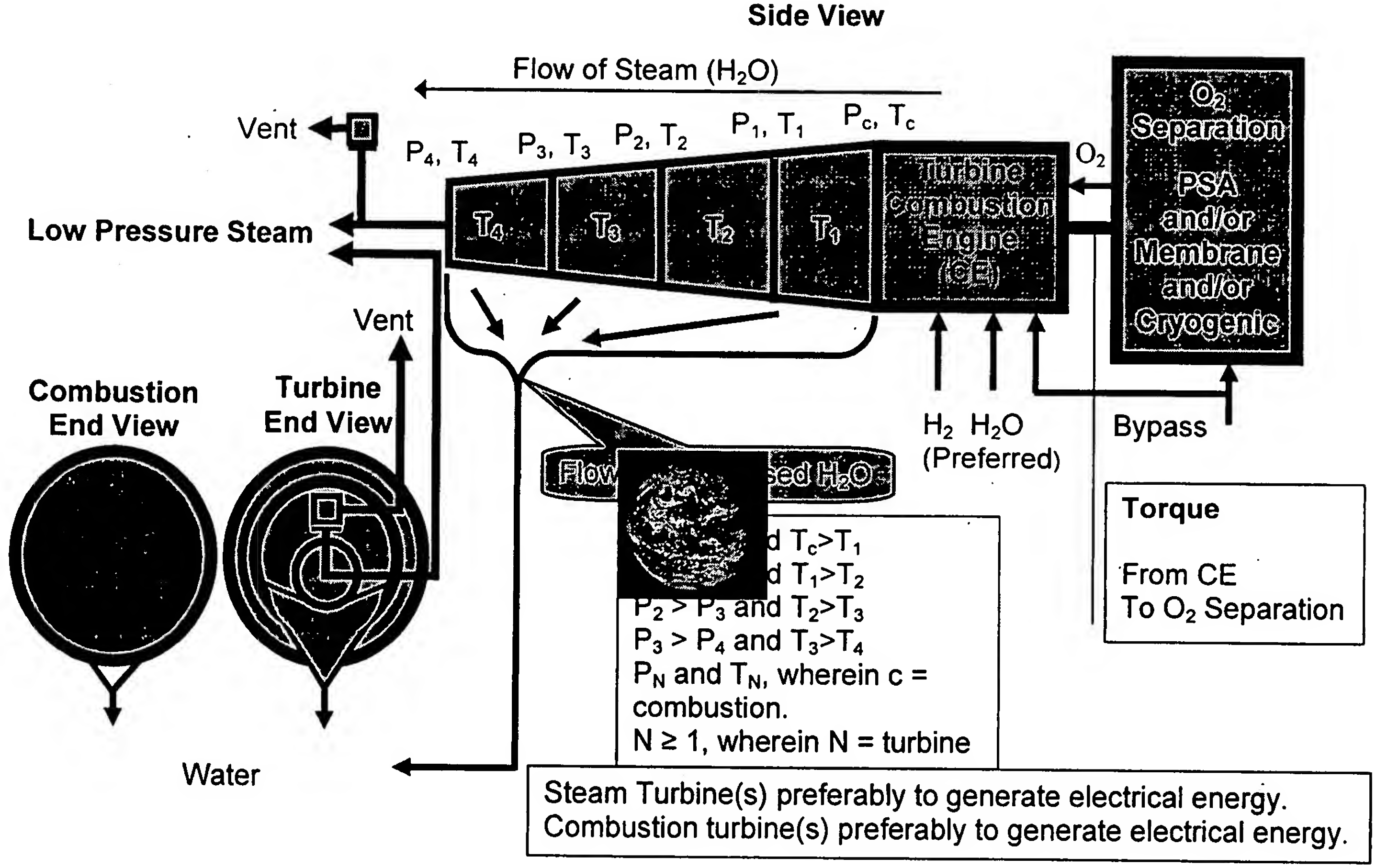
**Combination of Known and Established Processes**

**Science is Complete; Engineering Required**

**Very Significant WW Market**

**Protected By PCT US 03/11250 & U.S. 10/790,316**

# ClearValue's Water Combustion Technology
# Combustion/Steam Turbine Configuration
# Electrical Generation

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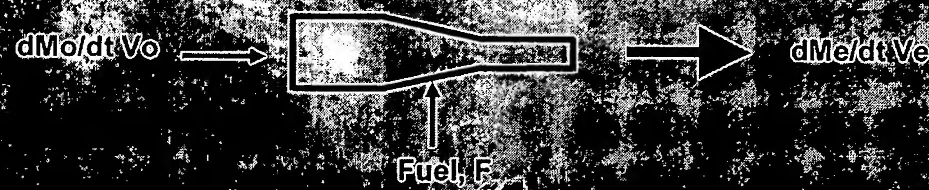
# ClearValue's Water Combustion Technology
## Jet Propulsion




Thrust = dMe/dt Ve – dMo/dt Vo, Let $M_e$ = Mo + $M_F$, $M_F$ = mass of fuel.

$F = {}_{to}\int^{t1} {}_{Vo}\int^{Ve}$ Me – Mo = ${}_{to}\int^{t1} {}_{Vo}\int^{Ve}$ [illegible] – Mo = ${}_{to}\int^{t1} {}_{Vo}\int^{Ve} M_F$

$F_{WCT} = {}_{to}\int^{t1} {}_{Vo}\int^{Ve}\{M_{H2} + M_{O2} + M_{H2O}$ [illegible] $M_{AIR}\}$, for Kerosene $F = {}_{to}\int^{t1} {}_{Vo}\int^{Ve}\{M_{FK} + M_{AIR}\}$

Is, $F_{WCT} \geq F$ [illegible] is, $\{M_{H2} + M_{O2} + M_{H2O}\} \geq \{M_K\}$ ?
And, [illegible] instead of $O_2$, then is $\{M_{H2} +$ [illegible] $\} \geq \{M_K + M_{AIR}\}$ ?

$\Delta H_{H2}$ = 51,5[illegible] BTU/lb. $\Delta H_K$ = 19,314 BTU/lb.

$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$ | $C_{14}H_{30}$ + 43/2 $O_2$ → 14 $CO_2$ + 15 $H_2O$
1 lb. + 8 lb. → 9 lb. | 1 lb. + 3.47 lb. → 3[illegible] lb. + 1.36 lb.

$Cp_K$ = 0.6 BTU °F/lb. $Cp_{H2O}$ = [illegible] BTU °F/lb. $Cp_{H2}$ = 3.45 BTU °F/lb., $Cp_{AIR}$ = 0.46 BTU °F/lb.
$\Delta H_{V\,H2O}$ = 974 BTU/lb., $\Delta H_{H2O}$ = 1434 BTU/lb. Kerosene(K) a liquid, $H_2$ vaporized @ STP

$\Delta H$ Combustion = $\Sigma\ \Delta H$'s
$\Delta H_K = Cp_K$ (lb. K)(1000) + $Cp_{AIR}$ (3.47/0.18)(1000) + $Cp_{AIR}$(lb. AIR)(1000)
19,314 = (0.6)(1)(1000) + 0.46(3.47/0.18)(1000) + 0.46(lb. Air)(1000) .

∴ **For Kerosene, 1 lb. K/40.3 lb. air = 41.3 lb. thrust @ 1000°F.**
$\Delta H_{H2}$ = 3.45(1)(1000) + 0.46(8/0.18)(1000) + 0.46(lb. $H_2O$)(1000) + 974(lb. $H_2O$)
51,571 = 3450 + 20,444 + 1434(lb. $H_2O$), $H_2O$ cooling = 19.3 lb., Air = 8/0.18 = 44.4 lb.

∴ $H_2$, 1 lb. $H_2$/44.4 lb. air/19.3 lb. $H_2O$ = 64.7 lb. thrust (This design requires a 10% increase in air compression @ 1000°F.)

∴ $H_2$ w/air cooling, 0.37 lb. $H_2$/39.22 lb. Air = 39.6 lb. Thrust, 5% reduction.

∴ Lb. thrust/lb. fuel: $H_2$/Air = 39.6; Kerosene/Air = 41.3; $H_2/H_2O$ = 3.18

∴ Previous $H_2$ issues at high altitudes obvious; $H_2$ requires 30% more air.

∴ $H_2$/Air Engines Require Increased Air Compression Systems.

∴ Liquid $O_2$ and $H_2O$ supplement combustion at high altitude operation, and

∴ $H_2O$ & The Joule Thompson Effect Can Cool Exhaust Reducing Heat Trail.

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# Water Combustion Technology Development

## Stage 1 – Proof-of-Concept

Four Proof-of-Concept Units $400k; or, One Individually $150k.

1. Racing Go Cart (Cartage),
2. Model "Jet" Airplane,
3. 1 kW Power Plant, and
4. 1 Ton HVAC

## Stage 2 - Prototyping

1. Capital Requirement $25M ($9M Facility + $4M X 4)
2. Develop 4 Prototypes:
   - Internal Combustion,
   - Electrical Turbine,
   - Jet Propulsion Turbine, and
   - Environmental Heating.

| Resource ($ k's) | 1Q | 2Q | [illegible] | 4Q | 5Q | Totals |
|---|---|---|---|---|---|---|
| Office and Facility Cost | 175.0 | 175.0 | 175.0 | 190.0 | 190.0 | 905.0 |
| COO & Mgmt. | 75.0 | 75.0 | 75.0 | 100.0 | 100.0 | 425.0 |
| Business Support Staff | 30.0 | 30.0 | 30.0 | 45.0 | 60.0 | 195.0 |
| Patent/Legal Expense | 10.0 | 20.0 | 40.0 | 80.0 | 100.0 | 250.0 |
| 4 Engineers | 180.0 | 180.0 | 180.0 | 180.0 | 180.0 | 900.0 |
| 5 Prototype Designers | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 500.0 |
| Consulting fees | 75.0 | 75.0 | 150.0 | 150.0 | 150.0 | 600.0 |
| Technical Support Staff | 300.0 | 300.0 | 300.0 | 300.0 | 300.0 | 1,500.0 |
| Facility Support Staff | 30.0 | 30.0 | 30.0 | 45.0 | 65.0 | 200.0 |
| Laboratory Equipment | 400.0 | 300.0 | 200.0 | 150.0 | 150.0 | 1,200.0 |
| Tooling/Equipment | 600.0 | 400.0 | 300.0 | 200.0 | 100.0 | 1,600 |
| Travel/Entertainment | 75.0 | 75.0 | 100.0 | 150.0 | 200.0 | 600.0 |
| Misc. | 25.0 | 25.0 | 25.0 | 25.0 | 25.0 | [illegible] |
| Totals | 2,075.0 | 1,785.0 | 1,705.0 | 1,715.0 | 1,720.0 | [illegible] |

## Stage 3 – Technology Development/Market Validation

1. Identify Required Development/Commercialization P
2. Reducing Licensing Contract/Preferred Business IP
3. Business Development in All Four Industries

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# Water Combustion Technology Financial Plan

## Stage 2 – Technology Development/Market Validation Partners

Licensing Fees:
- $200 M for Transportation,
- $100 M for Energy Combustion/Steam Turbine,
- $ 50 M for Jet Propulsion, and
- $ 25 M for Environmental Heating Partner.

## Stage 3 – Translation/Market Penetration

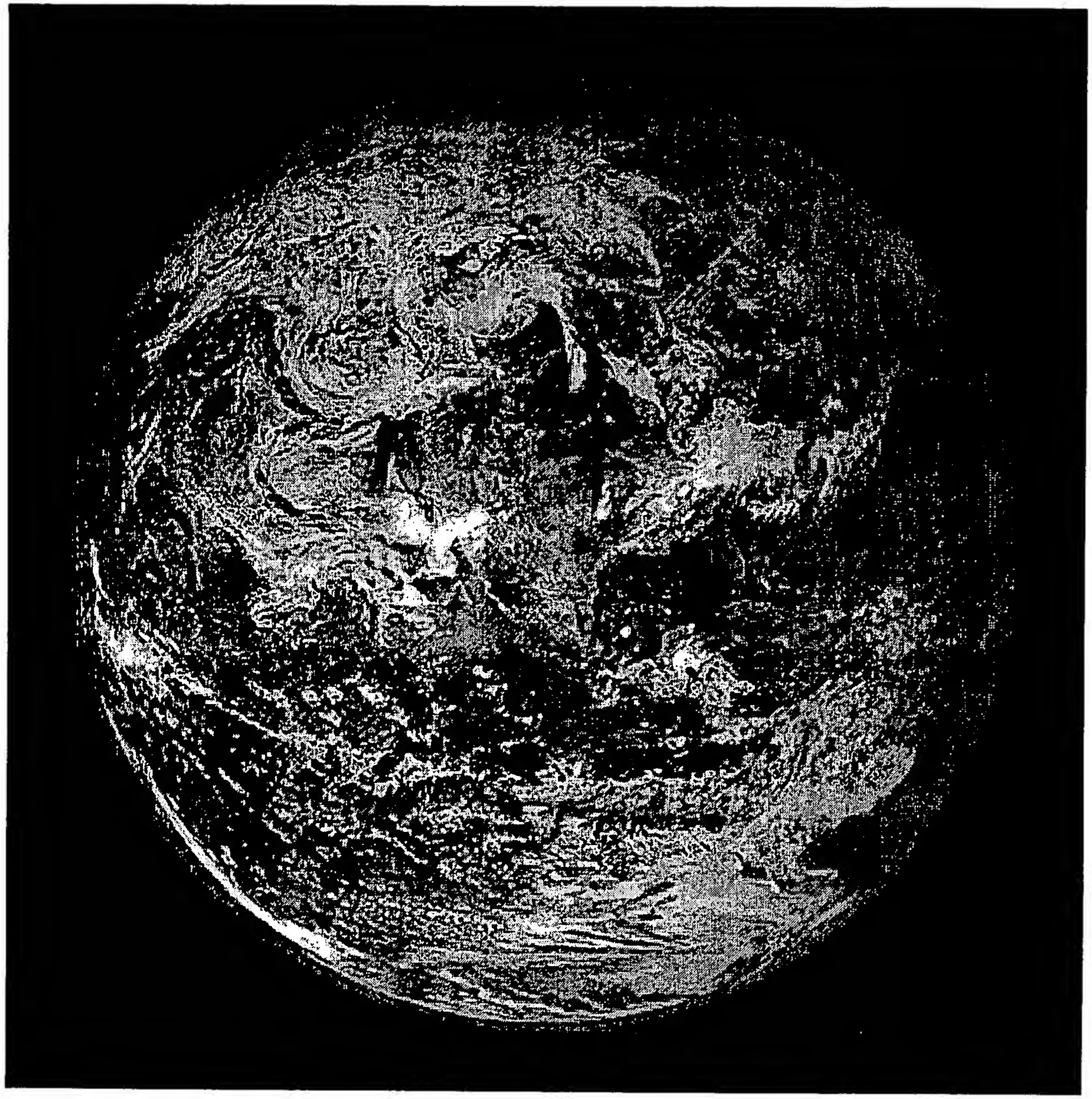
Licensing Fees:
- $500 M for Transportation (10 + planned),
- $500 M for Power/Steam Turbine Equipment (10 + planned),
- $100 M for Jet Propulsion (10 + planned), and
- $ 50 M for HVAC (20 + planned).

- Requires WW Political and Business Development,
- Requires Support of Energy Sector,
- Royalties – TBD, Estimated:

1. Transportation - $500 per engine / $500 per vehicle,
2. Electrical Generation - $0.50 per KWH Capacity / $0.020 per KWH
3. Jet Propulsion - $10k to $250k per Engine / $10k to $10 M per
4. HVAC - $100 per ton / $10 per burner.

## Success Requirements

- World Class Technology/Business development,
- Political Support Within Each Commercialization County,
- Flow Forward/Flow Back Technology Within Licensing Agreements,
- Translation Across Entire Market Application Opportunities, and
- Continued World Class R&D.



**Thank You For Your Time and Interest!**

**WCT – WBT Showcase – Presentation Script**

1. Slide "1" – The Earth
   a. The Earth – Our Home. The Earth is mostly water; our bodies are mostly water. ClearValue's innovations improve our water, our air, our health, our world.
   b. Pure water and clean air are a ClearValue. ClearValue is the leader in water chemistry, bio-chemistry and thermodynamics. ***Wait***

2. Slide "2" – The Lake
   ***Wait*** – We are beginning to see shortages of pure water and clean air. **These significant needs will change our world, one way or another. We can lead or be left behind.**

3. Slide "3" – Vision and Mission
   Water and hydrogen will be more important than any other resource in a few years. ClearValue has become a leader in water and in hydrogen technology. ClearValue is a technology company, innovating a new tomorrow.

4. Slide "4" – Intellectual Property
   ClearValue has sustainable competitive advantage. ClearValue's patents have ClearValue poised for significant growth and investor return.

5. Slide "5" – ClearValue
   ClearValue was founded in 1994. ClearValue has 6 divisions. Today we focus on combustion, ClearValue's hydrogen engine. ***Wait***

6. Slide "6" – Air Purity Issues
   ***Wait*** Before Katrina…Before the Inconvenient Truth…ClearValue knew what we all know now. Oxides of carbon, nitrogen and sulfur are ruining our home. If we do not, the oceans will rise and an ice age will form; we could be remembered as the "selfish generation".

7. Slide "7" – Traditional Combustion – Hydrocarbons and Air
   Today, every $ of gasoline is $0.15 of power. Every $ of your electric bill is $0.25 to $0.35 of electricity from natural gas or coal…We can do better. ***Wait***

8. Slide "8" – The Water Combustion Technology, The WCT
   ***Wait*** - Water is the answer; a water engine works with, rather than against, the Earth. ClearValue's engine is pure water and 60% efficiency, a major improvement. ClearValue's engines are more powerful while having longer life. ClearValue's engines are more economical.

   Fuel cells are not the answer. Fuel cells: 1) Require platinum we do not have, 2) Are too expensive, 3) Produce $NO_X$; and 4) Do not provide that power, we all love.

Hydrogen and air are not the answer - 15% efficiency. And, hydrogen burns hotter converting more air to $NO_X$, contaminating our home.

9. Slide "9" – The WCT
   ClearValue's engine follows the first and the second laws of thermodynamics using equipment in use today.

10. Slide "10" – The WCT Internal Combustion Engine
    **1/3 engine size** and **3 times the power**. The radiator is replaced with a cryogenic unit producing pure oxygen and nitrogen from air. Pure oxygen to the engine. Cryogenic nitrogen to store hydrogen at cryogenic temperatures, thus eliminating the hydrogen storage challenge.

11. Slide "11" – The WCT Power Plant
    Power Plants with no boilers, cooling towers, heat exchangers or emissions equipment. A Power Plant will simply be an air separator, a combustion turbine and steam turbines; ½ the equipment. Austin Energy confirms that a 1 MW unit will fit on the bed of a tractor trailer. ***Wait***

12. Slide "12" – Jet Propulsion
    ***Wait*** - Airbus spent $1 Billion and failed; ClearValue has the solution. The challenge and the solution to a hydrogen jet engine are thermodynamic. At 3 times the energy per pound, hydrogen provides greater distance and/or load carrying capacity.

13. Slide "13" – Technology Development
    Due to ClearValue's "War with the French", ClearValue is in need of financial partners.

14. Slide "14" – Business Development/Translation
    ***Wait*** Licensing is to be within current industries. All licenses are to have flow forward and flow back technology provisions.

15. Slide "15" – Earth – Thank You!
    This is our home…We must take care of our home; better care will lead to change…Change leads to opportunity. ClearValue is a socially responsible technology and business which can be a ClearValue to all!

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(19) United States

(12) Patent Application Publication

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(43) Pub. Date: Sep. 15, 2005

Haase

(54) WATER COMBUSTION TECHNOLOGY - METHODS, PROCESSES, SYSTEMS AND APPARATUS FOR THE COMBUSTION OF HYDROGEN AND OXYGEN

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(21) Appl. No.: 10/790,316

(22) Filed: Mar. 1, 2004

**Related U.S. Application Data**

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(60) Provisional application No. 60/447,880, filed on Feb. 14, 2003. Provisional application No. 60/404,644, filed on Aug. 19, 2002. Provisional application No. 60/379,587, filed on May 10, 2002. Provisional application No. 60/371,768, filed on Apr. 11, 2002.

**Publication Classification**

(51) Int. Cl.[7] .................................................... F03G 6/00

(52) U.S. Cl. ........................................................... 60/641.8

(57) **ABSTRACT**

This invention presents improved combustion methods, systems, engines and apparatus utilizing $H_2$, $O_2$ and $H_2O$ as fuel, thereby providing environmentally friendly combustion products, as well as improved fuel and energy management methods, systems, engines and apparatus. The Water Combustion Technology; WCT, is based upon water ($H_2O$) chemistry, more specifically $H_2O$ combustion chemistry and thermodynamics. WCT does not use any hydrocarbon fuel source, rather the WCT uses $H_2$ preferably with $O_2$ and secondarily with air. The WCT significantly improves the thermodynamics of combustion, thereby significantly improving the efficiency of combustion, utilizing the first and second laws of thermodynamics. The WCT preferably controls combustion temperature with $H_2O$ and secondarily with air in the combustion chamber. The WCT preferably recycles exhaust gas energy as fuel converted from water. The WCT minimizes external cooling loops and minimizes exhaust and/or exhaust energy, thereby maximizing available work and internal energy while minimizing enthalpy and entropy losses.

**WCT Symbols in Flow Diagrams**

| Symbol | Description | Notes |
|---|---|---|
| | Clutch | Used to transfer $E_W$ to at least one of a flywheel and a generator. Clutch preferably engages during periods of little to no work and disengaged during periods of work. Design and assembly to be as known in the art. |
| | Flywheel | Used to store rotational kinetic energy during periods of little to no work; rotational energy to be utilized during periods of work. |
| | Generator | Used to generate electrical energy. Generator can be of the type to generate an alternating current (A/C), such as in power generation applications or a Dynamo to generate a direct current (D/C) to power electrolysis. A/C current can be turned into D/C with an A/C to D/C converter and D/C can be turned into A/C with a D/C to A/C converter. |
| $H_2O$ Electrolysis | Electrolysis | Electrolysis of $H_2O$ to $O_2$ and $H_2$ is to be performed. Electrolysis is to be performed by methods and systems known in the art of electrolysis. It is most preferred that an electrolyte be present in the H2O to further electrolysis and the efficiency of electrolysis. It is preferred that the electrolysis unit be cooled. |
| | Air Line | Line primarily contains air. |
| | $O_2$ Line | Line primarily contains $O_2$. |
| | $N_2$ Line | Line primarily contains $N_2$. |
| | $H_2$ Line | Line primarily contains $H_2$. |
| | $H_2O$ Line | Line primarily contains $H_2O$. |
| | Products Line | Line primarily contains combustion products, preferably $H_2O$, yet can be $H_2O$ and X, wherein X is $N_2$, $CO_X$ and $NO_X$ and can contain $SO_X$. |
| | Coolant (C) Line | Line symbol indicates flow of coolant, which is preferably used with electrolysis. C can be used with CE; however this is not preferred. C can be any type as is known in the art; coolant is preferred a mixture of water, glycol, corrosion inhibitor and dispersant. |
| | Control Line | Electrical or pneumatic line. Electrical wire carrying a small current, preferably 4 to 20 mA. Pneumatic line may carry a gas and/or a liquid under pressure. |
| | Flow Transmitter & Control Valve | Used in combination with control line and controller (CONT.) to control flow of fuel and/or coolant (C) |
| | Coolant Radiator | Used to release heat from coolant and pump back to heat source. Preferably used for electrolysis. Preferably used to cool oil for CE. It is not preferred to cool CE. |

**Figure 1**
**WCT Symbols in Flow Diagrams and in Figures 1 through 23A**

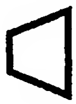
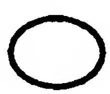
| Symbol | Description | Notes |
| --- | --- | --- |
| Combustion Engine (CE) | Combustion Engine | CE can be any combustion design as is known in the art, i.e. internal combustion engine, turbine, furnace, etc. CE combines fuel and ignites fuel with a spark generation device. Fuel is most preferably $O_2$, $H_2$ and $H_2O$. Fuel is preferably $O_2$ and $H_2$. Fuel can be used in combination with air. |
|  | Gas Compressor | Used in Cryogenic Refrigeration. Designs are plentiful in the art. Compressor symbols: A = Air, D1 = First Distillation, D2 = Second Distillation, O1 = $O_2$, H1 = $H_2$, O = $O_2$ Storage and H = $H_2$ Storage. |
|  | Joule-Thompson Expansion Valve | Two types are normally used in the art – 1. An expansion valve, 2. A cylinder. |
|  | Separation (Distillation Column) | Diameter and Height dependent upon separation efficiency and loading. Separation efficiency dependent upon compounds separated and column packing. Distillation Temperatures are relative to Separation Operating Pressure. Depending on the desired $O_2$ purity, the second $O_2/N_2$ separation column is optional. |
| Q X'fer | Heat Exchanger to cool compressed gases | During normal operation, it is preferred that the waste $N_2$ is coolant. Depending upon design, upon start-up water may be necessary for an efficient start-up. |
|  | Cryogenic Storage Tank | Tank is to be made of materials known in the art to withstand liquid cryogenic temperatures/pressure of $O_2$ and/or $H_2$. Tank may have refrigeration loop per Figure 13, which operates of off at least one of: the combustion engine, a battery and a fuel cell. |
| - + T | Turbine | Depending upon application, turbine is to be turned by steam, air or water movement. Turbine is preferred to generate electricity, preferably driving a generator and/or alternator. It is most preferred that the electricity performs electrolysis. |
| PC | Pressure Controller | Pressure controller can be of any design as is known in the art. PC protects downstream equipment from pressure surges. In high pressure surge situations, PC vents to the atmosphere. |
| Q | Energy in the form of heat | Energy is transferred (managed) during many methods, processes and systems of this invention. |
| C O N T | Fuel Mixture Controller | $H_2$, $O_2$, $H_2O$, air bypass and engine coolant. Controller manages fuel mixture ratios. $H_2O$ ratio in combustion is managed depending upon combustion temperature and/or engine temperature. Air bypass is to be managed depending upon $O_2$ tank level. Engine coolant loop dependant on high engine temperature. |

**Figure 1A**

**WCT Symbols in Flow Diagrams and in Figures 1 through 23A**

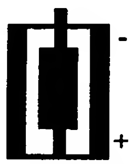
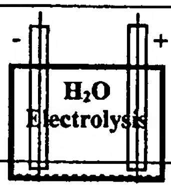
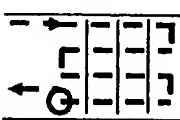
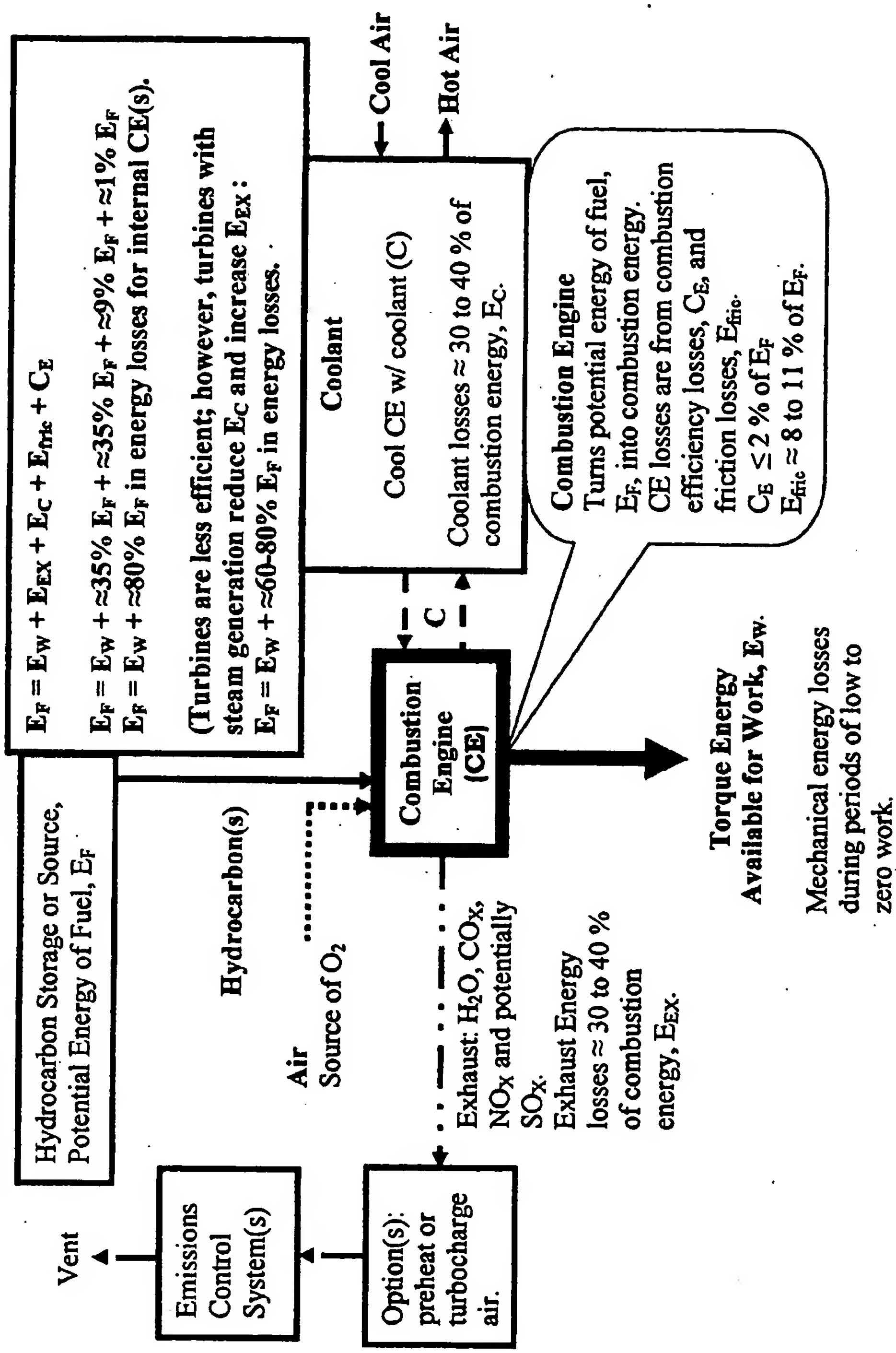
| Symbol | Description | Notes |
|---|---|---|
|  | Clutch | Used to transfer $E_W$ to at least one of a flywheel and a generator. Clutch preferably engages during periods of little to no work and disengaged during periods of work. Design and assembly to be as known in the art. |
|  | Flywheel | Used to store rotational kinetic energy during periods of little to no work; rotational energy to be utilized during periods of work. |
|   | Generator | Used to generate electrical energy. Generator can be of the type to generate an alternating current (A/C), such as in power generation applications or a Dynamo to generate a direct current (D/C) to power electrolysis. A/C current can be turned into D/C with an A/C to D/C converter and D/C can be turned into A/C with a D/C to A/C converter. |
|   | Electrolysis | Electrolysis of $H_2O$ to $O_2$ and $H_2$ is to be performed. Electrolysis is to be performed by methods and systems known in the art of electrolysis. It is most preferred that an electrolyte be present in the H2O to further electrolysis and the efficiency of electrolysis. It is preferred that the electrolysis unit be cooled. |
| | Air Line | Line primarily contains air. |
| ··············· | $O_2$ Line | Line primarily contains $O_2$. |
| — — — | $N_2$ Line | Line primarily contains $N_2$. |
| ——— | $H_2$ Line | Line primarily contains $H_2$. |
| — · — · · | $H_2O$ Line | Line primarily contains $H_2O$. |
| — · · — · | Products Line | Line primarily contains combustion products, preferably $H_2O$, yet can be $H_2O$ and X, wherein X is $N_2$, $CO_X$ and $NO_X$ and can contain $SO_X$. |
| - - - - - | Coolant (C) Line | Line symbol indicates flow of coolant, which is preferably used with electrolysis. C can be used with CE; however this is not preferred. C can be any type as is known in the art; coolant is preferred a mixture of water, glycol, corrosion inhibitor and dispersant. |
| ——— | Control Line | Electrical or pneumatic line. Electrical wire carrying a small current, preferably 4 to 20 mA. Pneumatic line may carry a gas and/or a liquid under pressure. |
|  | Flow Transmitter & Control Valve | Used in combination with control line and controller (CONT.) to control flow of fuel and/or coolant (C) |
|  | Coolant Radiator | Used to release heat from coolant and pump back to heat source. Preferably used for electrolysis. Preferably used to cool oil for CE. It is not preferred to cool CE. |

Figure 2

Traditional Combustion - Combustion Fueled by Hydrocarbon(s) and Air



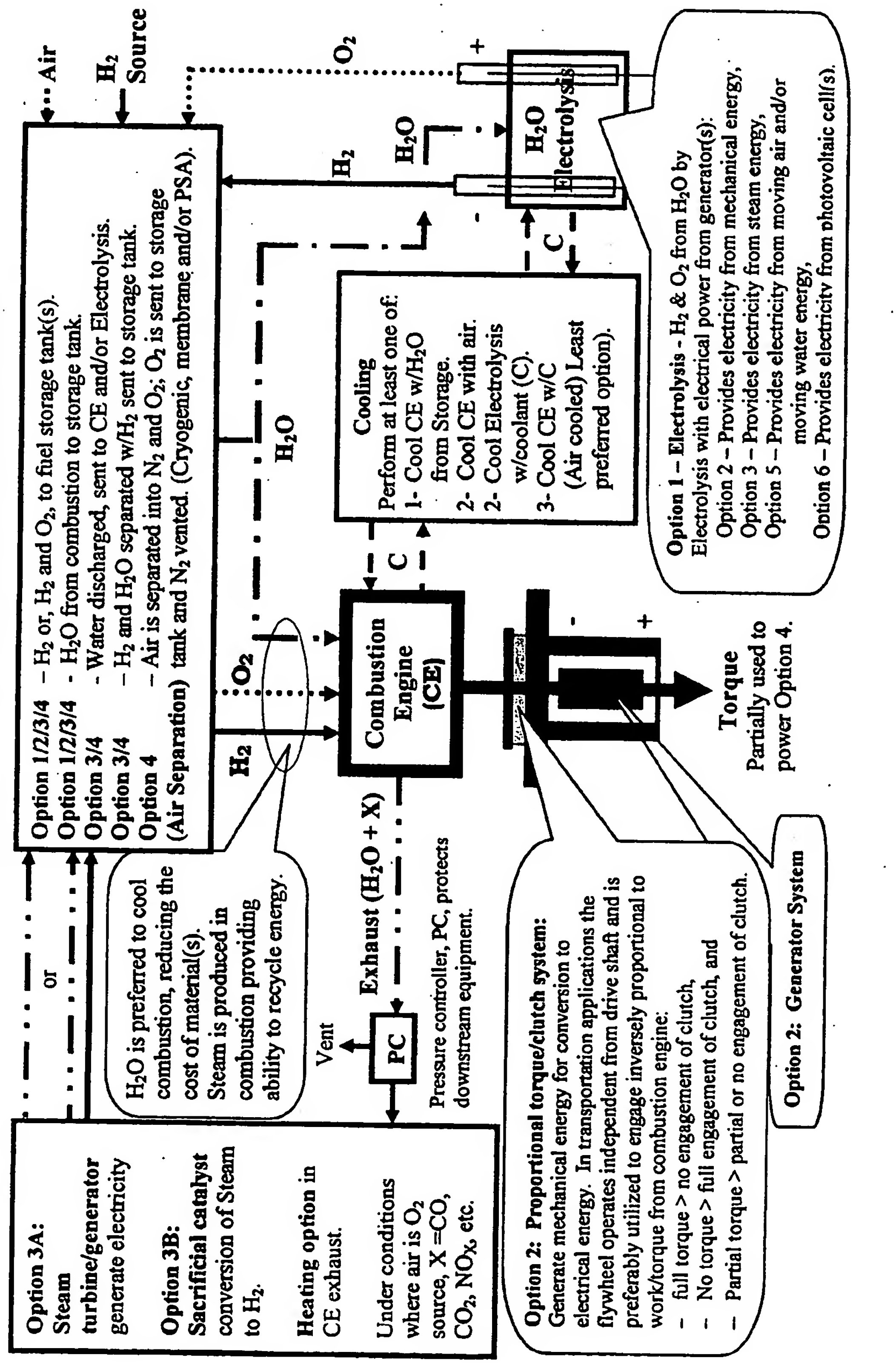



Figure 2A

Combustion Fueled by $H_2$ and $O_2$ Having Air as Alternate Source of $O_2$

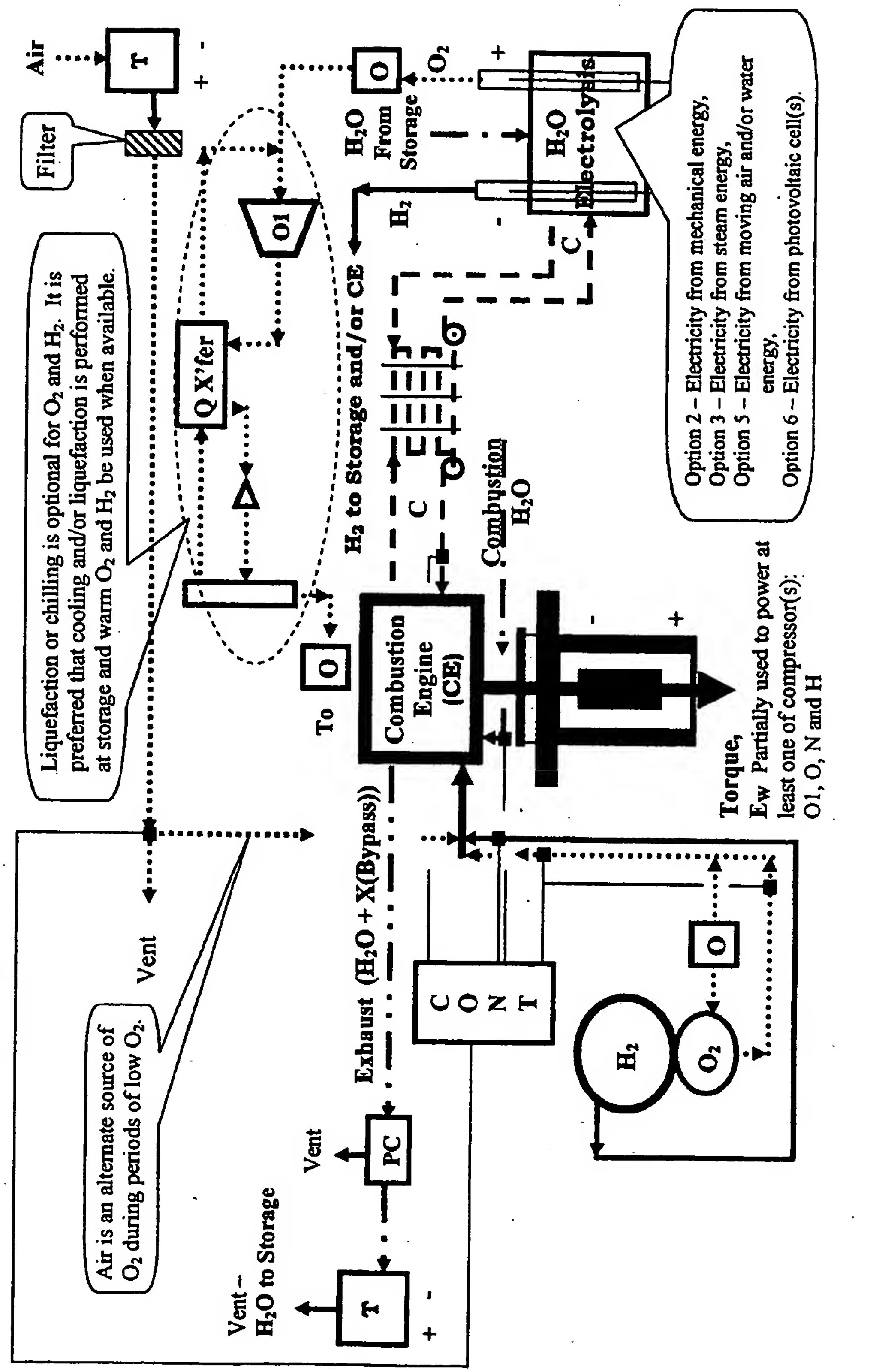



Figure 3

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate– Electrolysis

Figure 4

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate – $H_2$ Catalysis

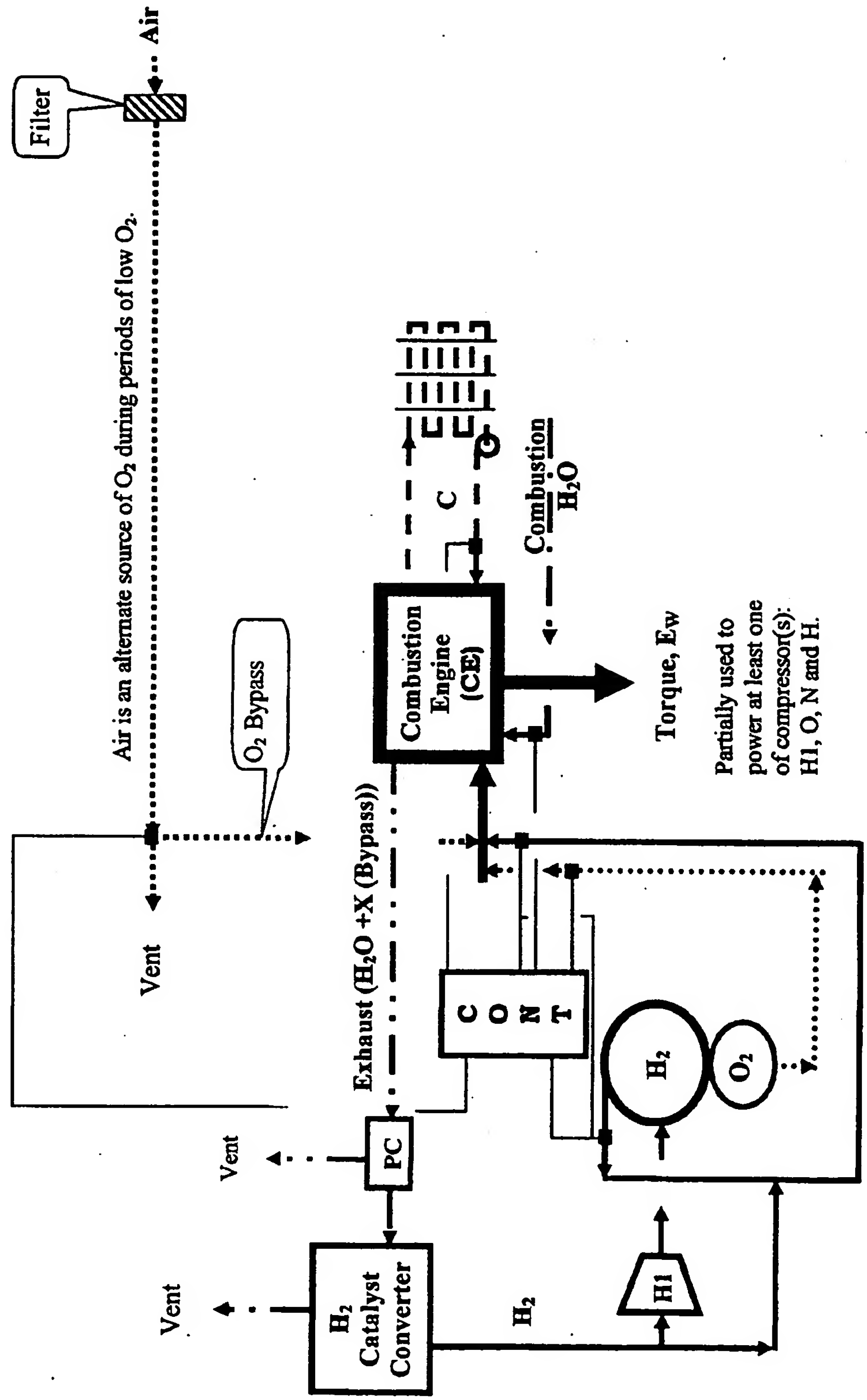


Figure 5

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $O_2$ Distillation

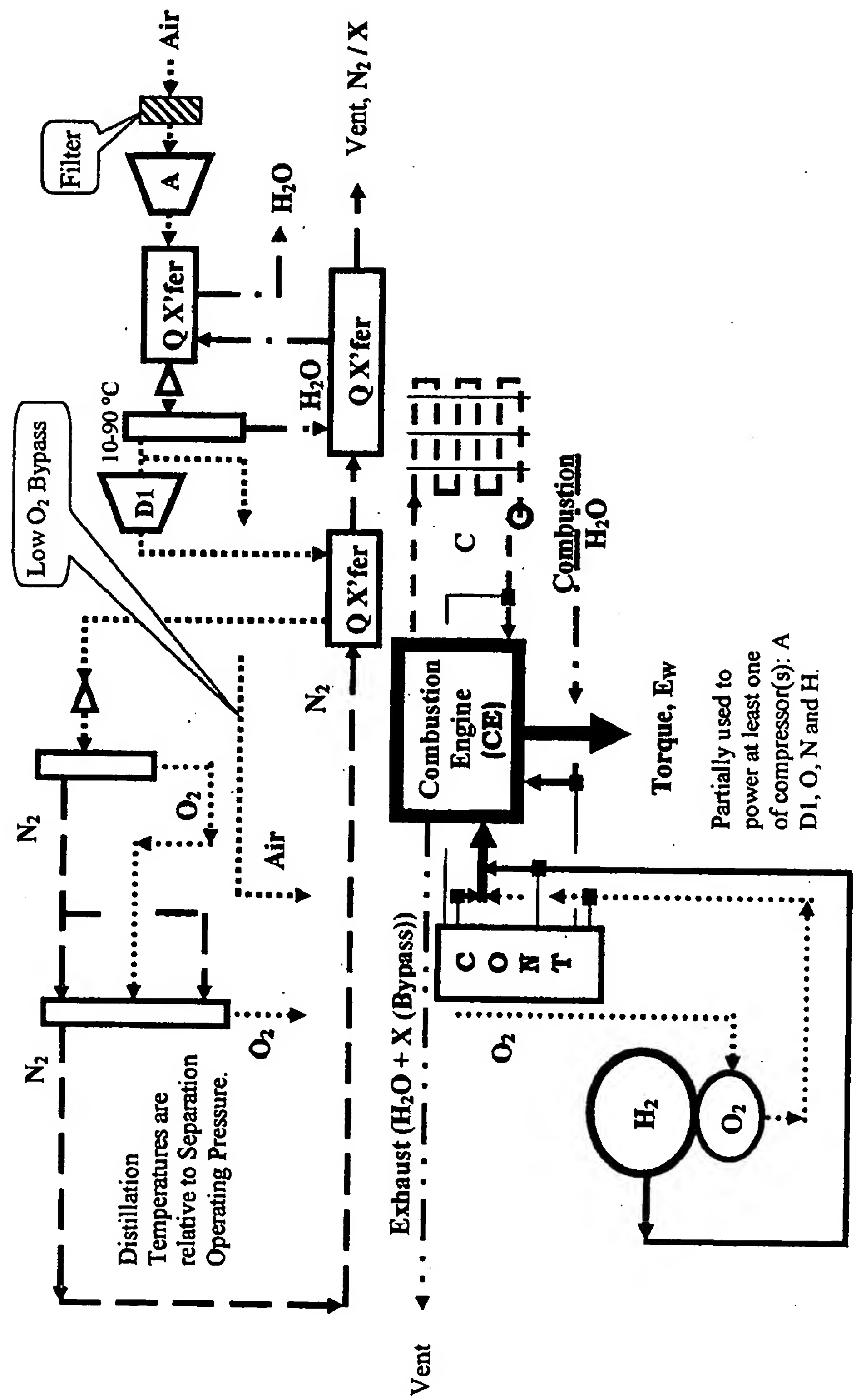


Figure 6

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate – Electrolysis – $H_2$ Catalysis

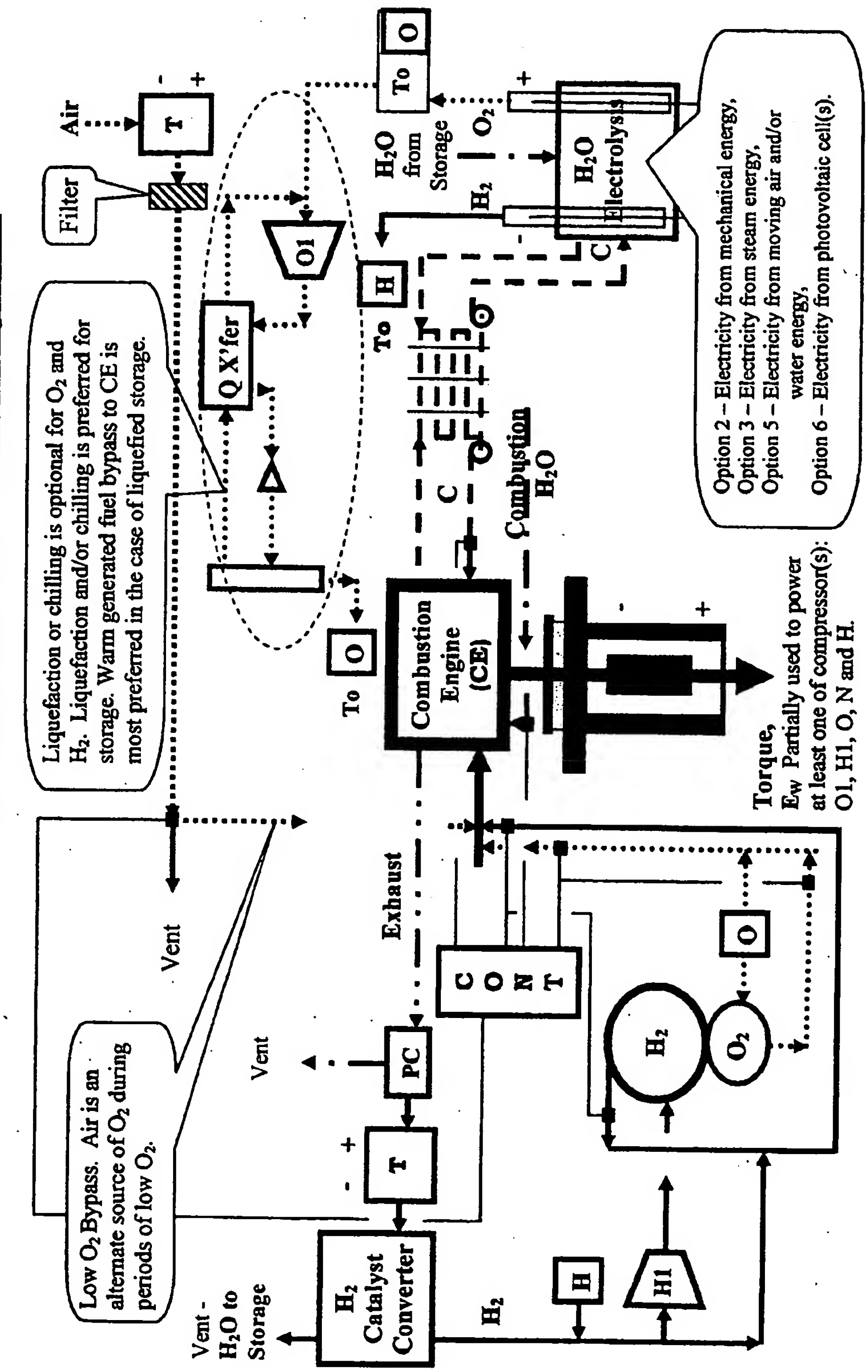


Figure 7

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - Electrolysis - $O_2$ Distillation

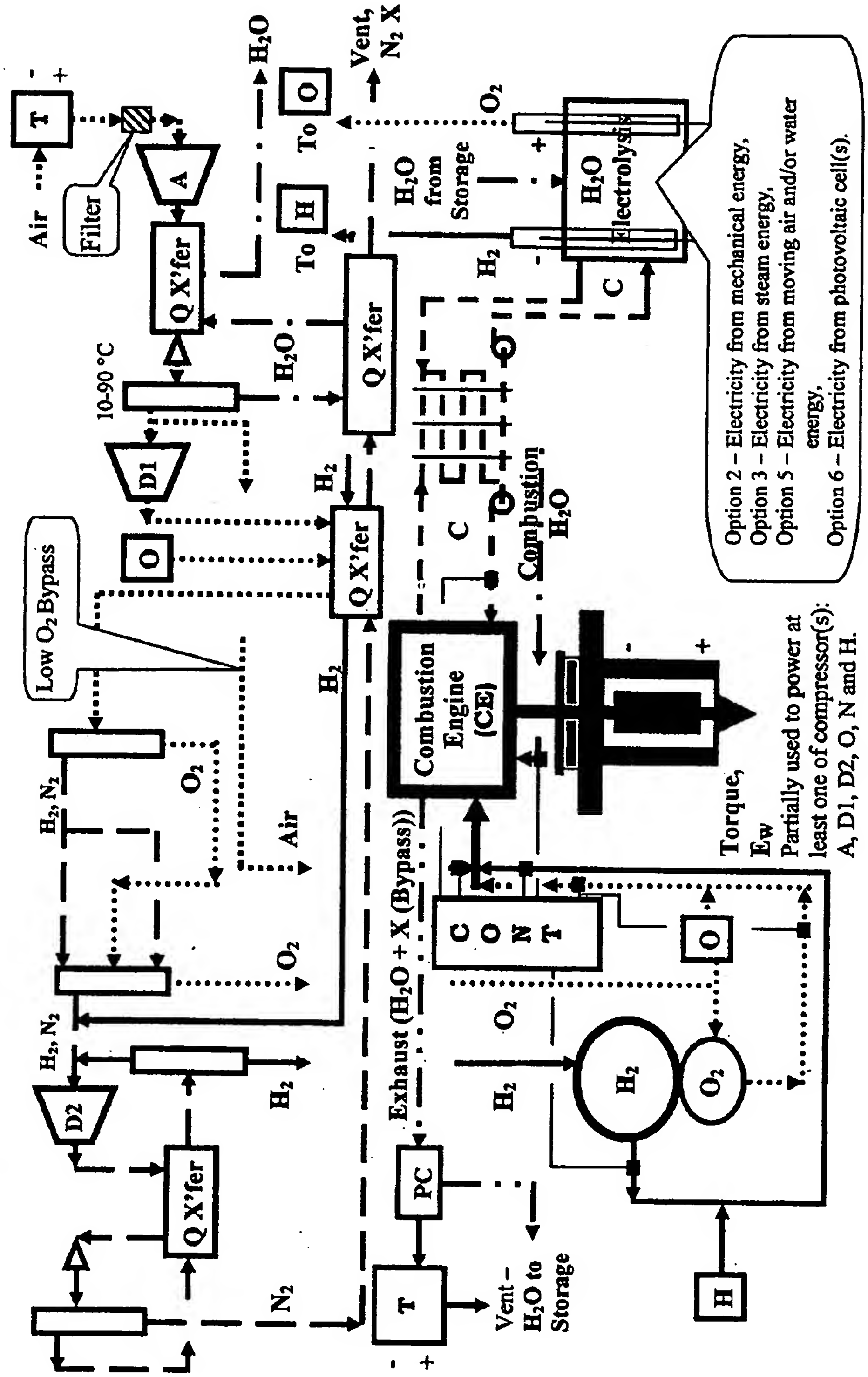


Figure 8

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - Electrolysis - $H_2$ Catalysis - $O_2$ Distillation

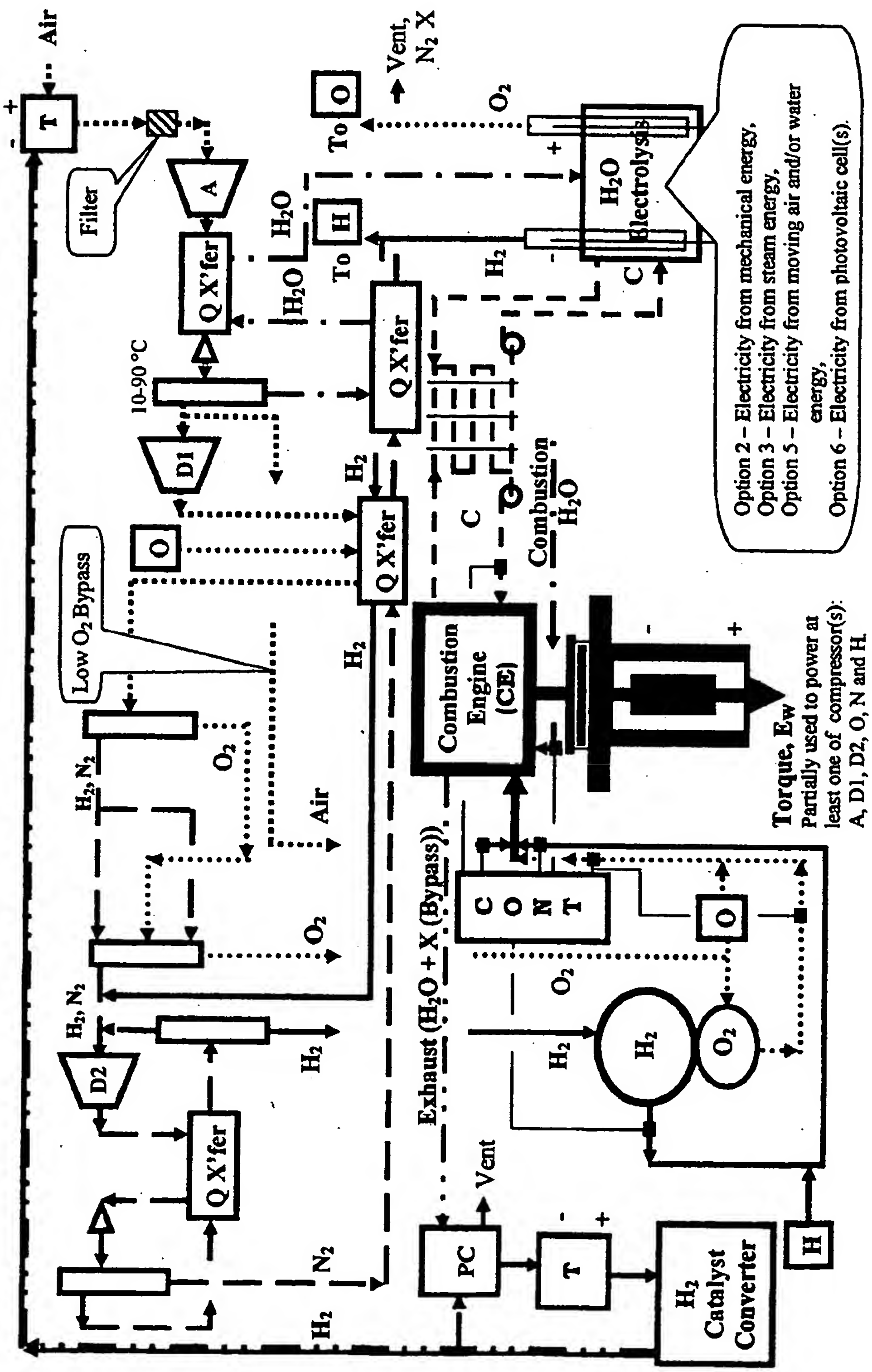


Figure 9

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $O_2$ Separation by Membranes or PSA

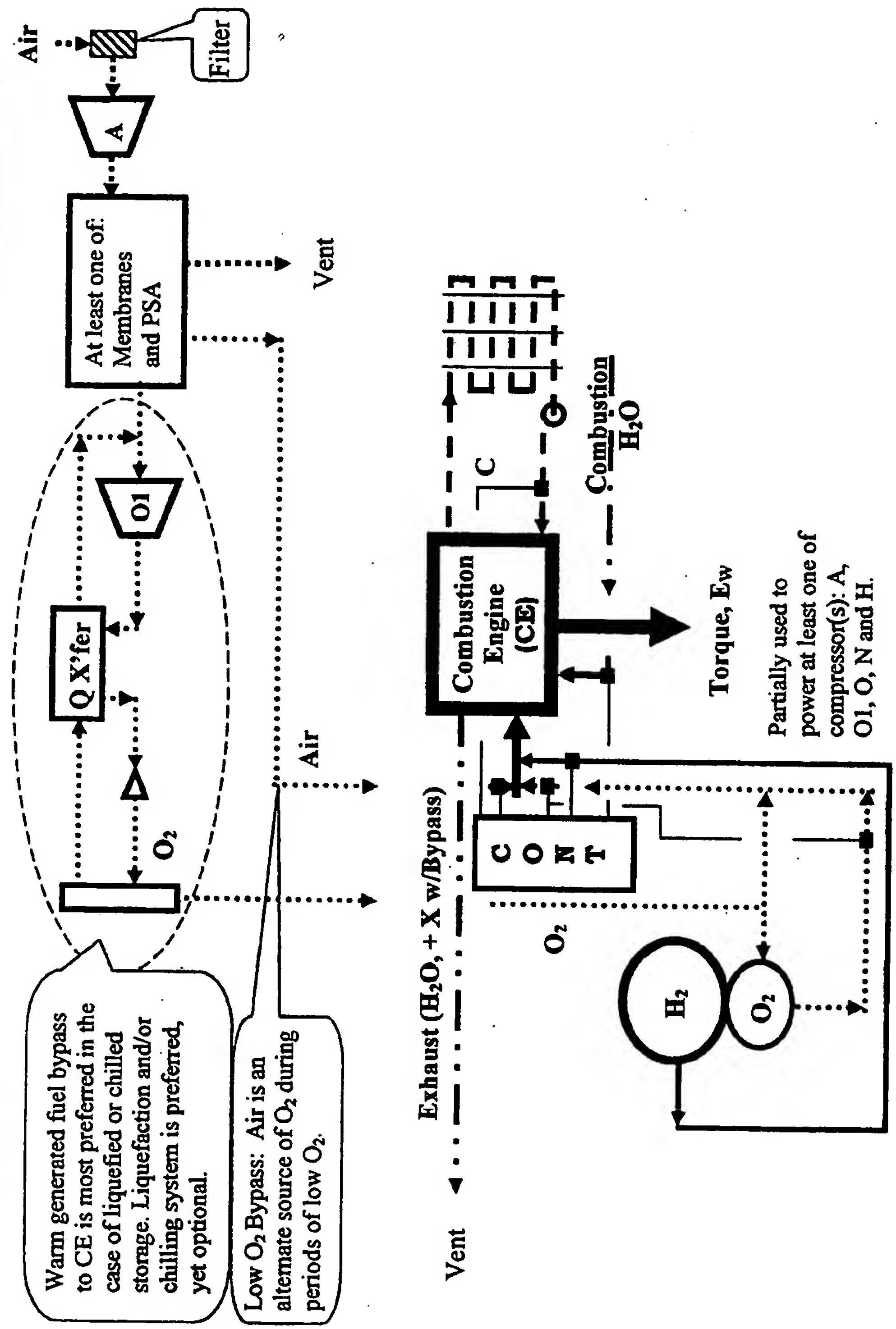
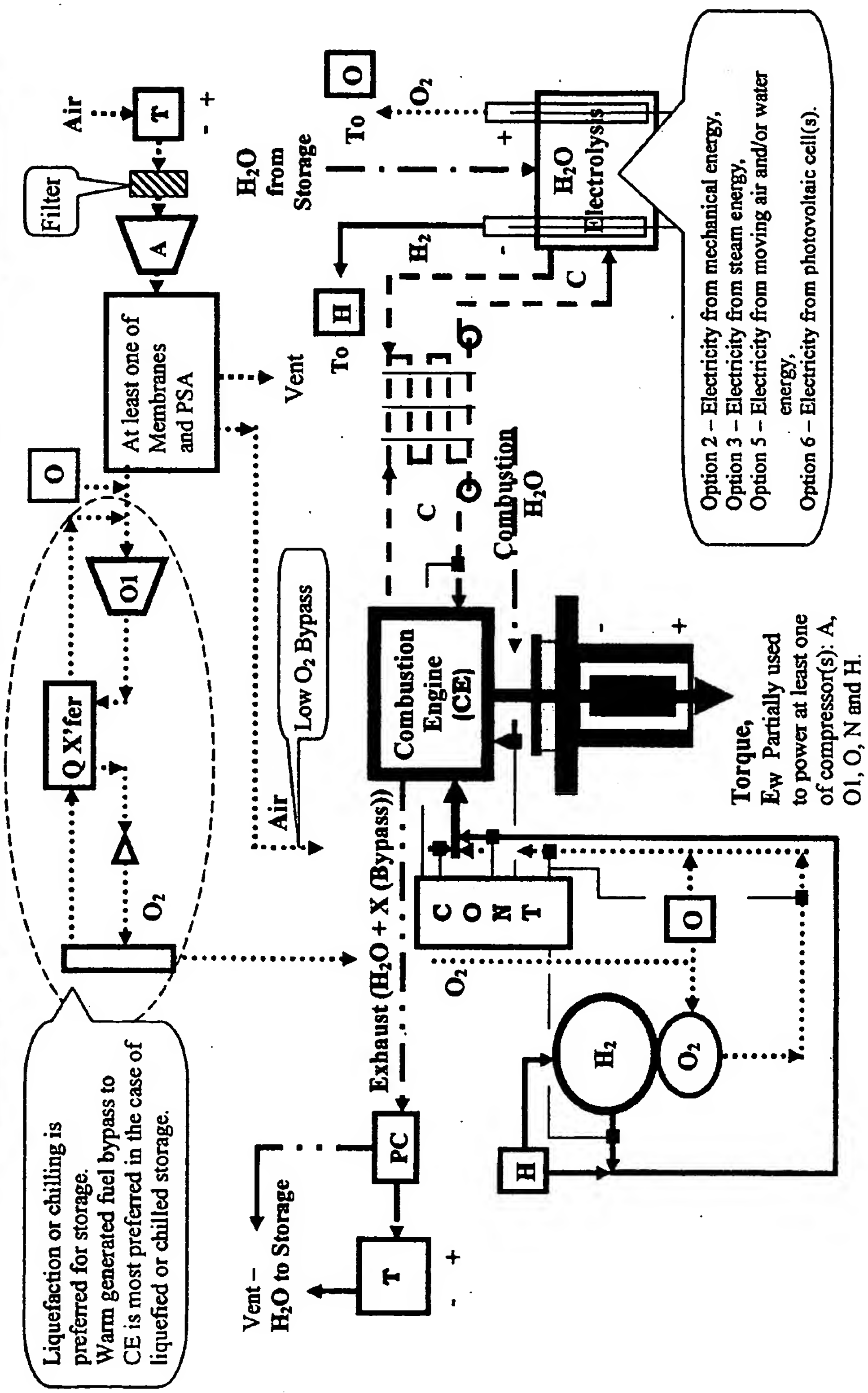


Figure 10

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - Electrolysis - $O_2$ Separation by Membranes or PSA



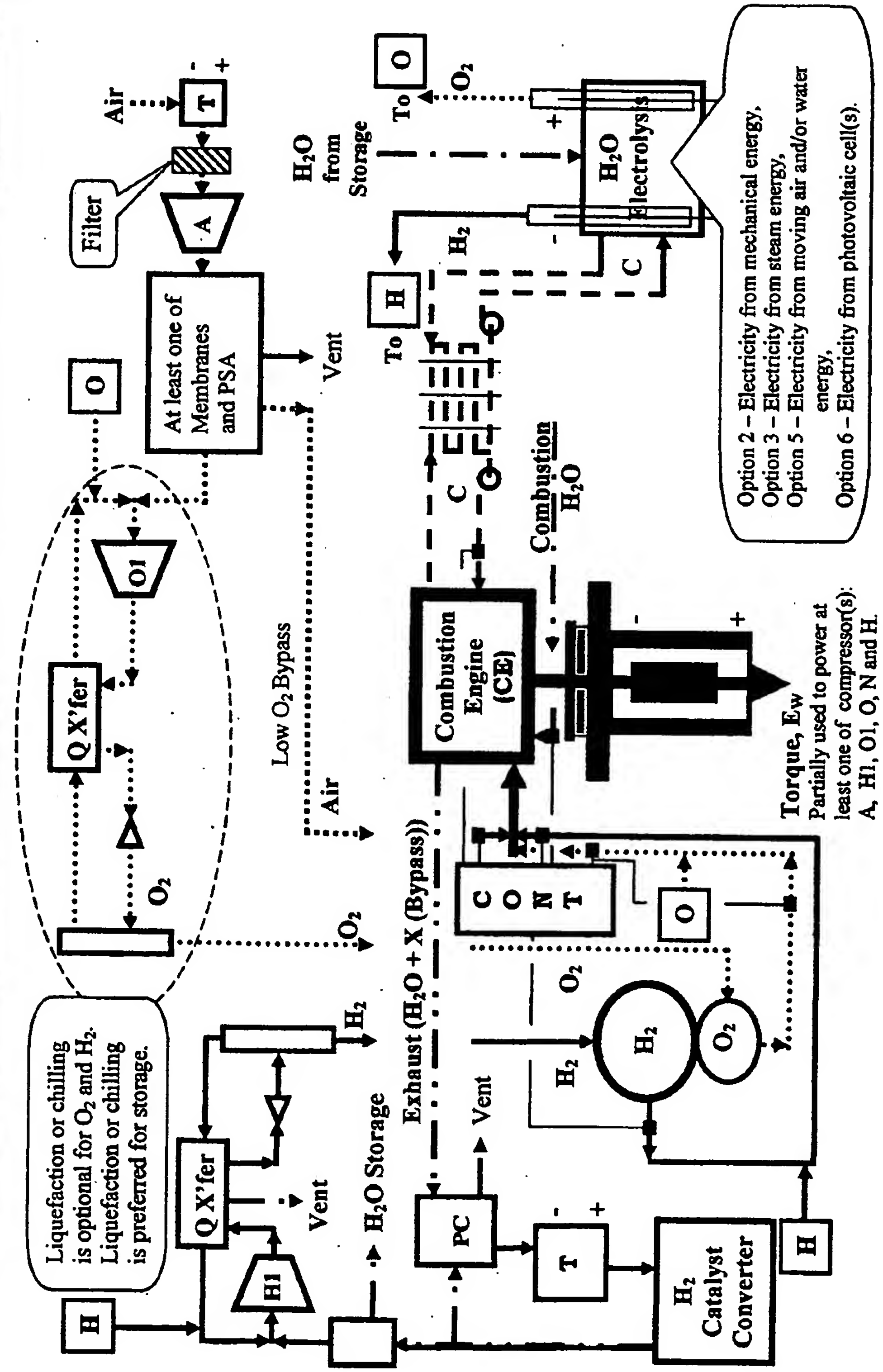



Figure 11

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - Electrolysis - $H_2$ Catalysis $O_2$ Separation by Membranes or PSA

Figure 12

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $H_2$ Catalysis - $O_2$ Distillation

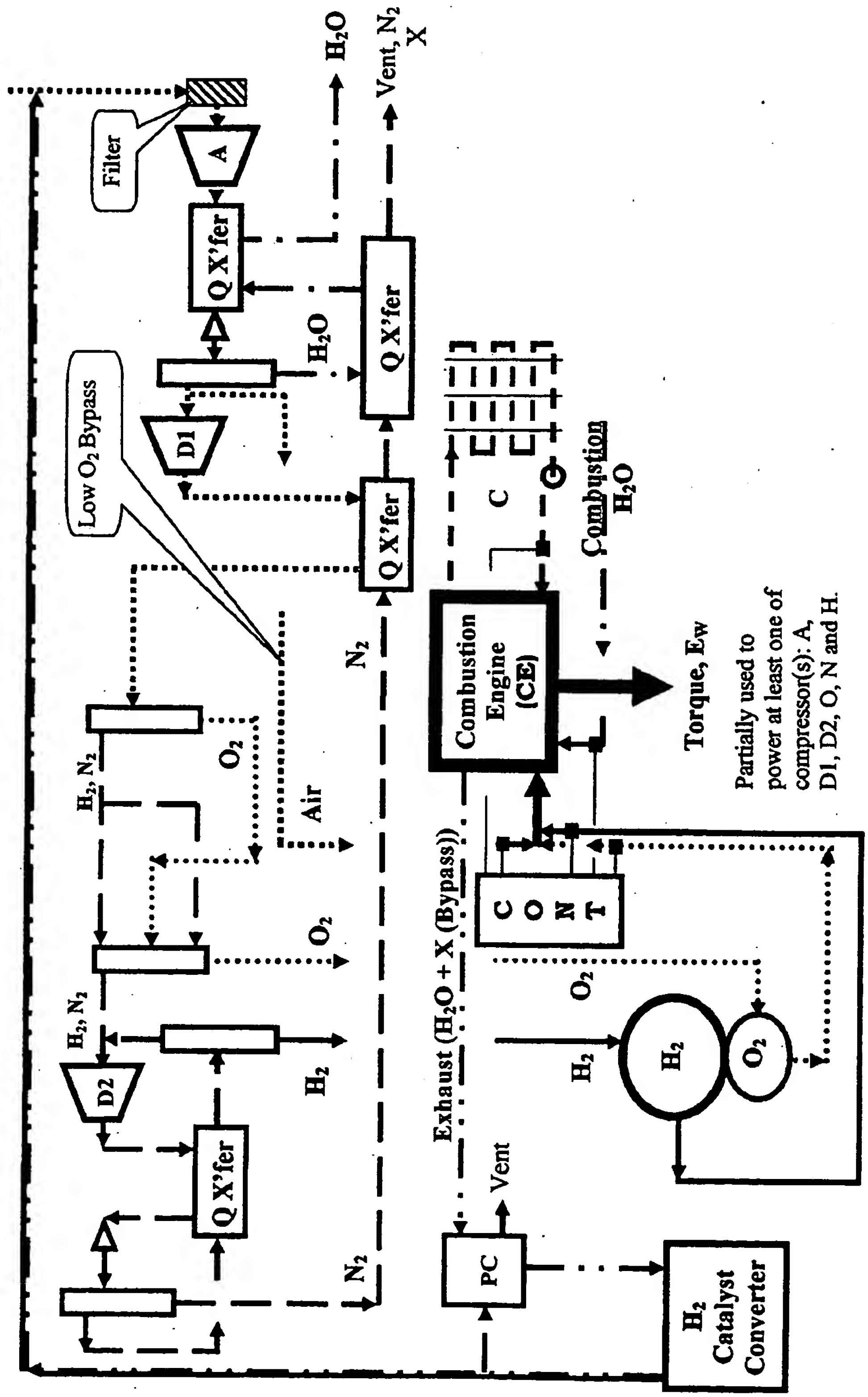


Figure 13

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $H_2$ Catalysis $O_2$ Separation by Membranes or PSA

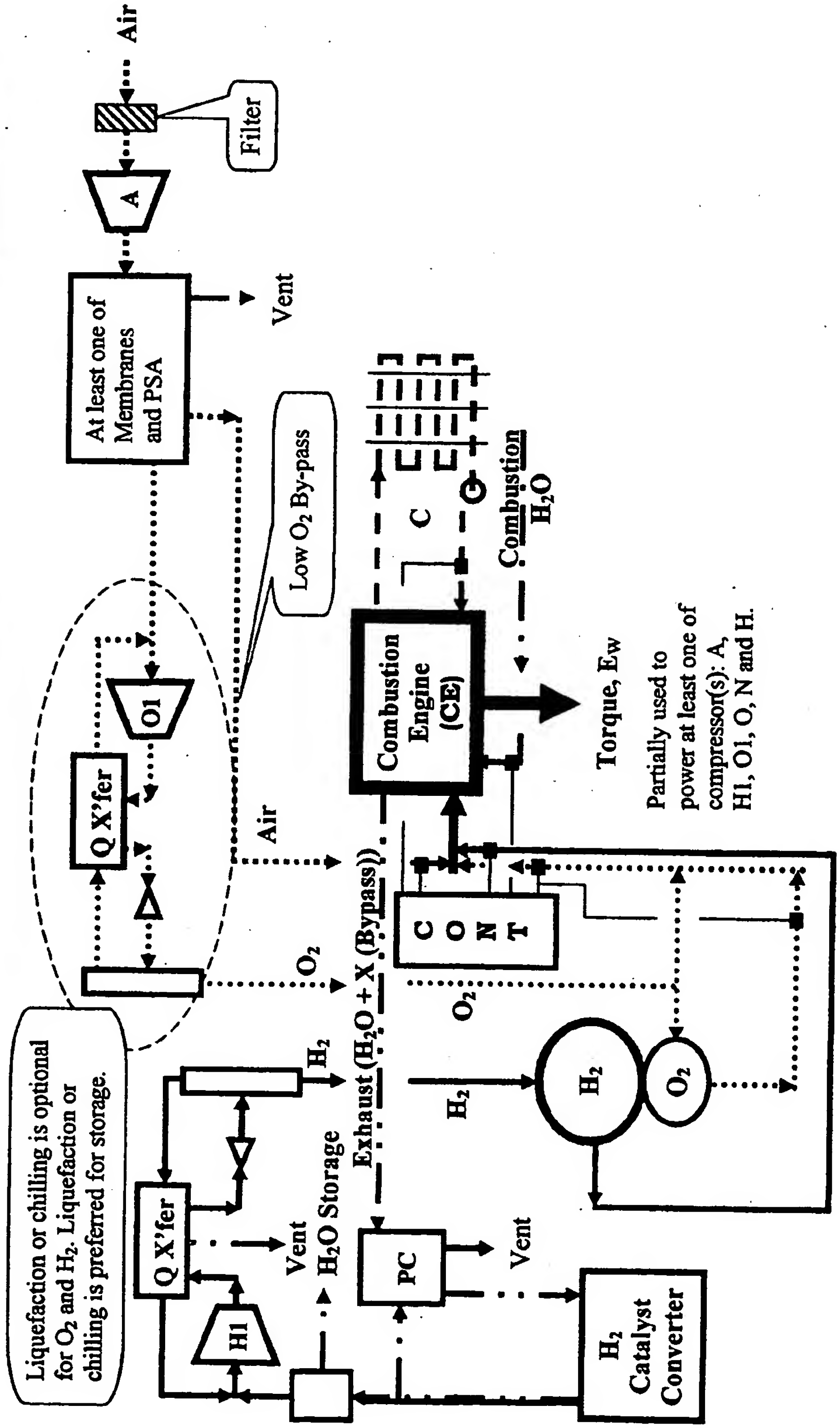


Figure 14

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate – $H_2$ Catalysis

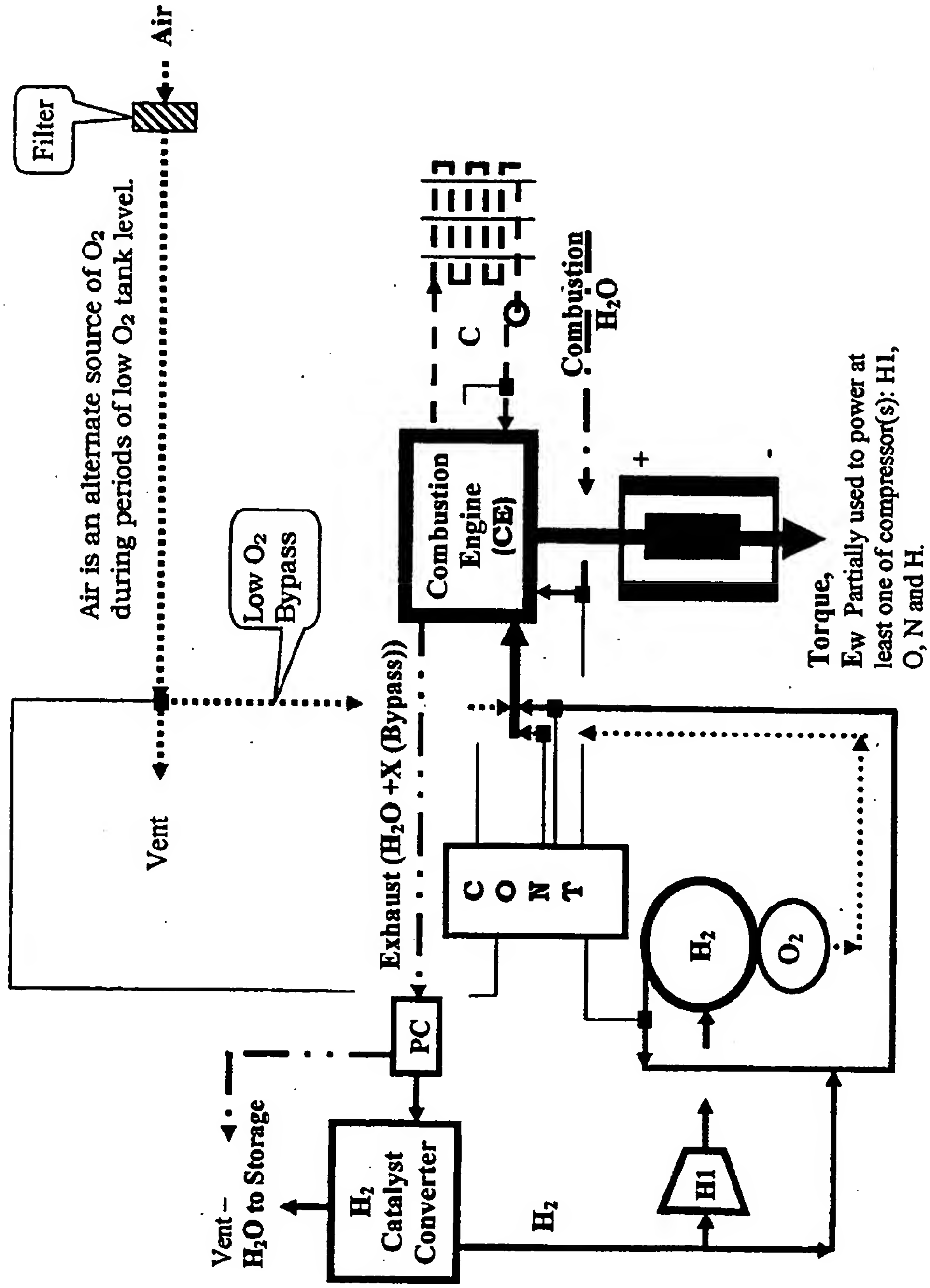


Figure 15

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $O_2$ Distillation

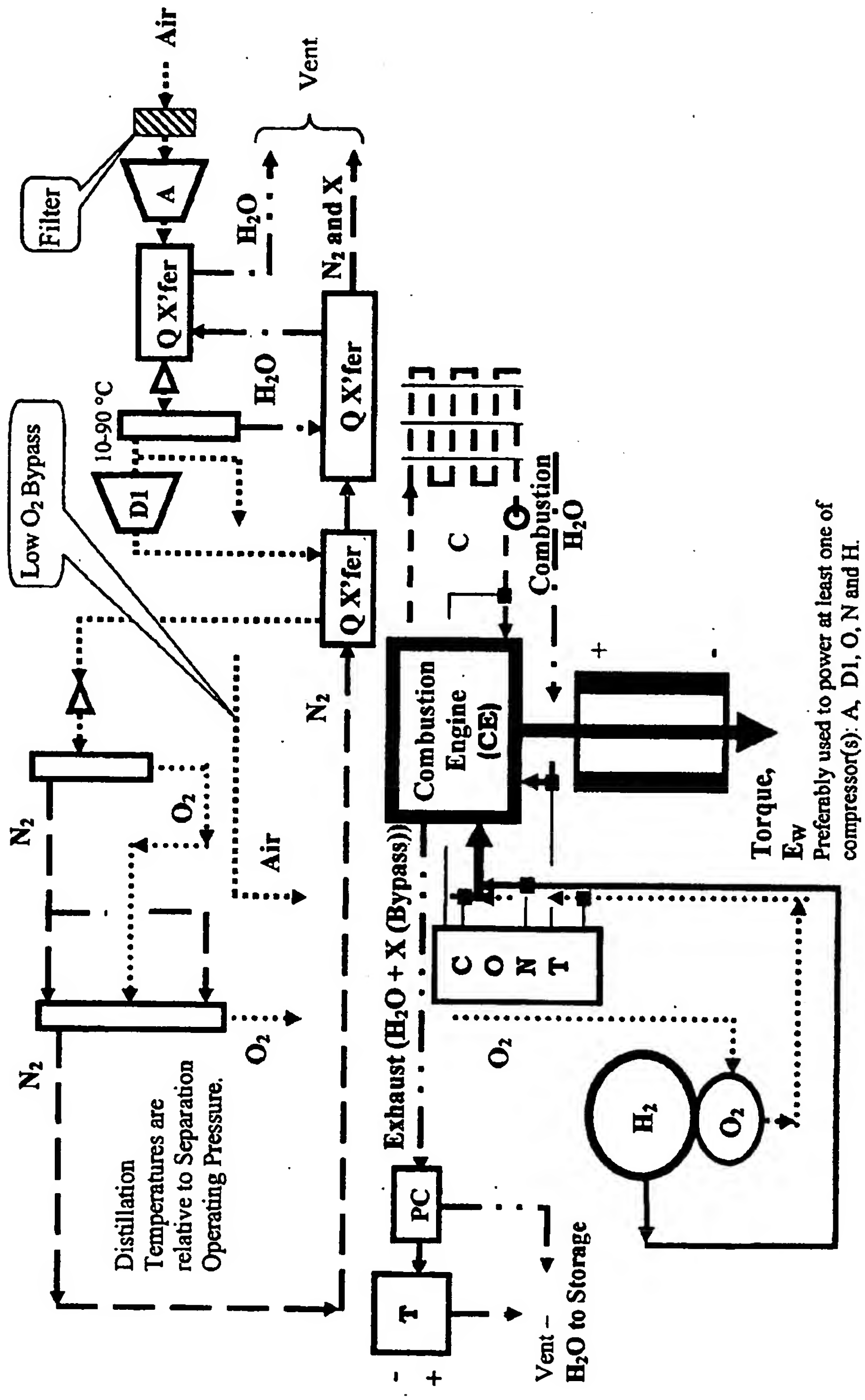


Figure 16

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $O_2$ Separation by Membranes or PSA

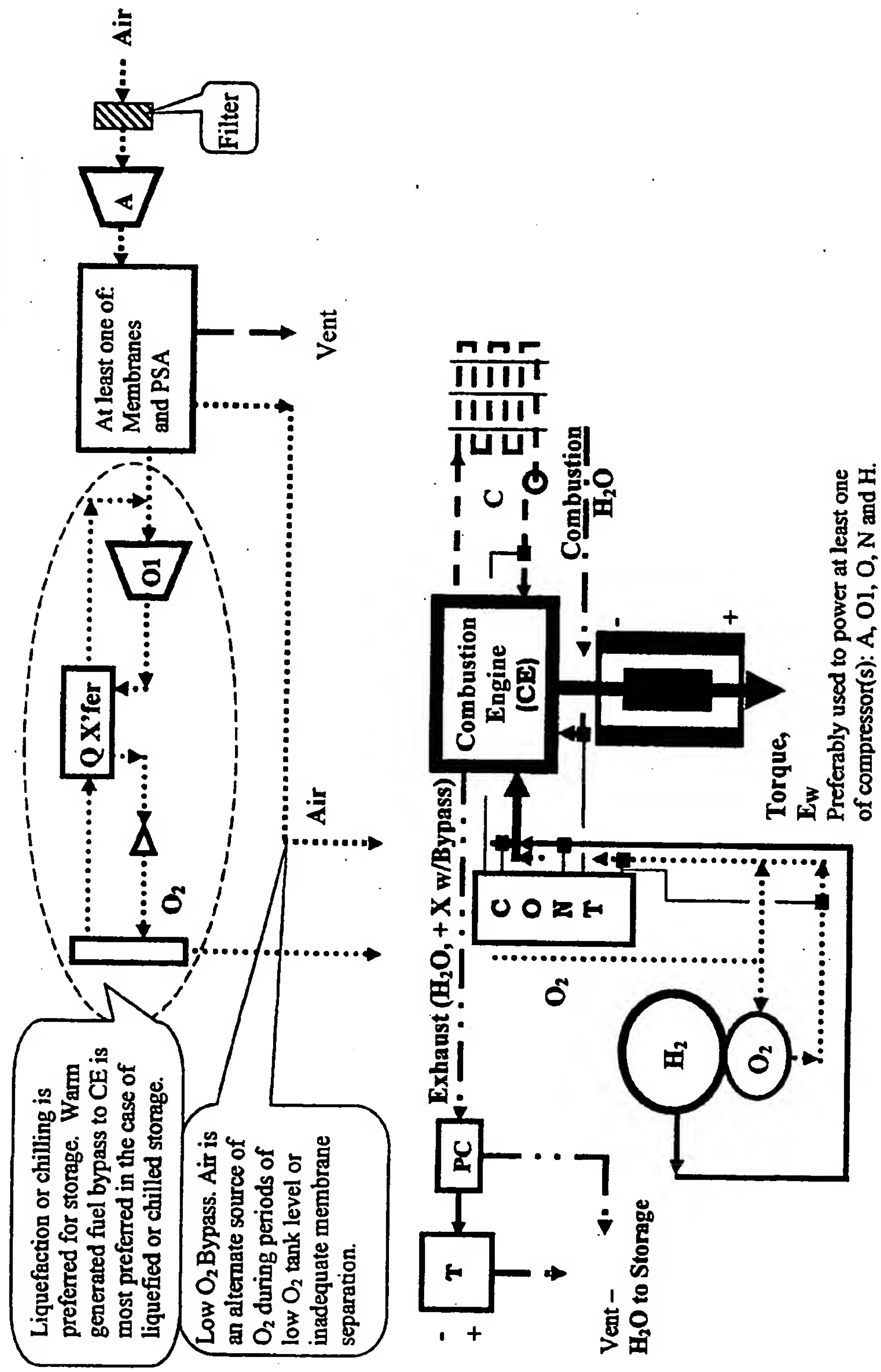


Figure 17

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $H_2$ Catalysis - $O_2$ Distillation

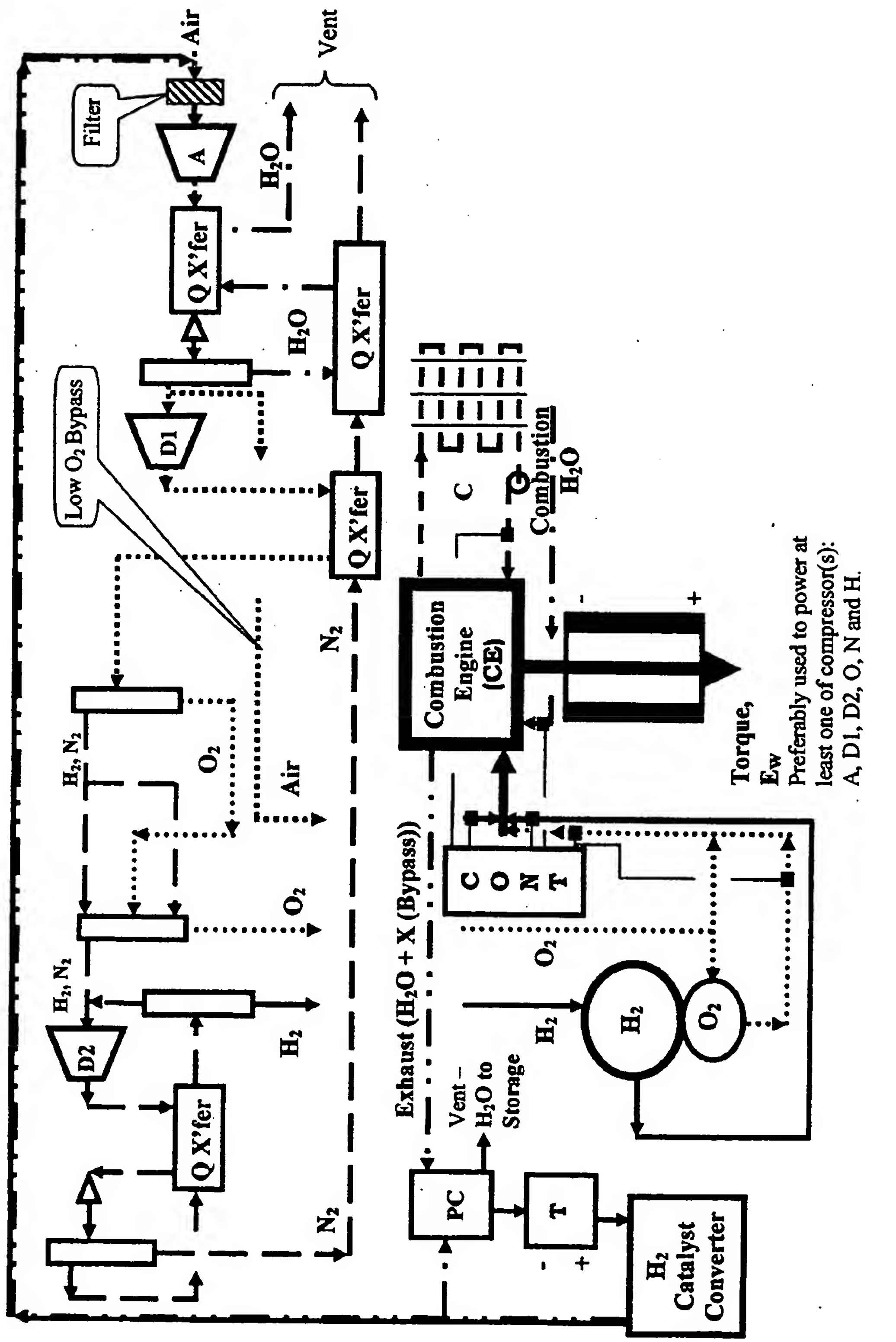


Figure 18

Combustion Fueled by $H_2$ and $O_2$ with Air as Alternate - $H_2$ Catalysis $O_2$ Separation by Membranes or PSA

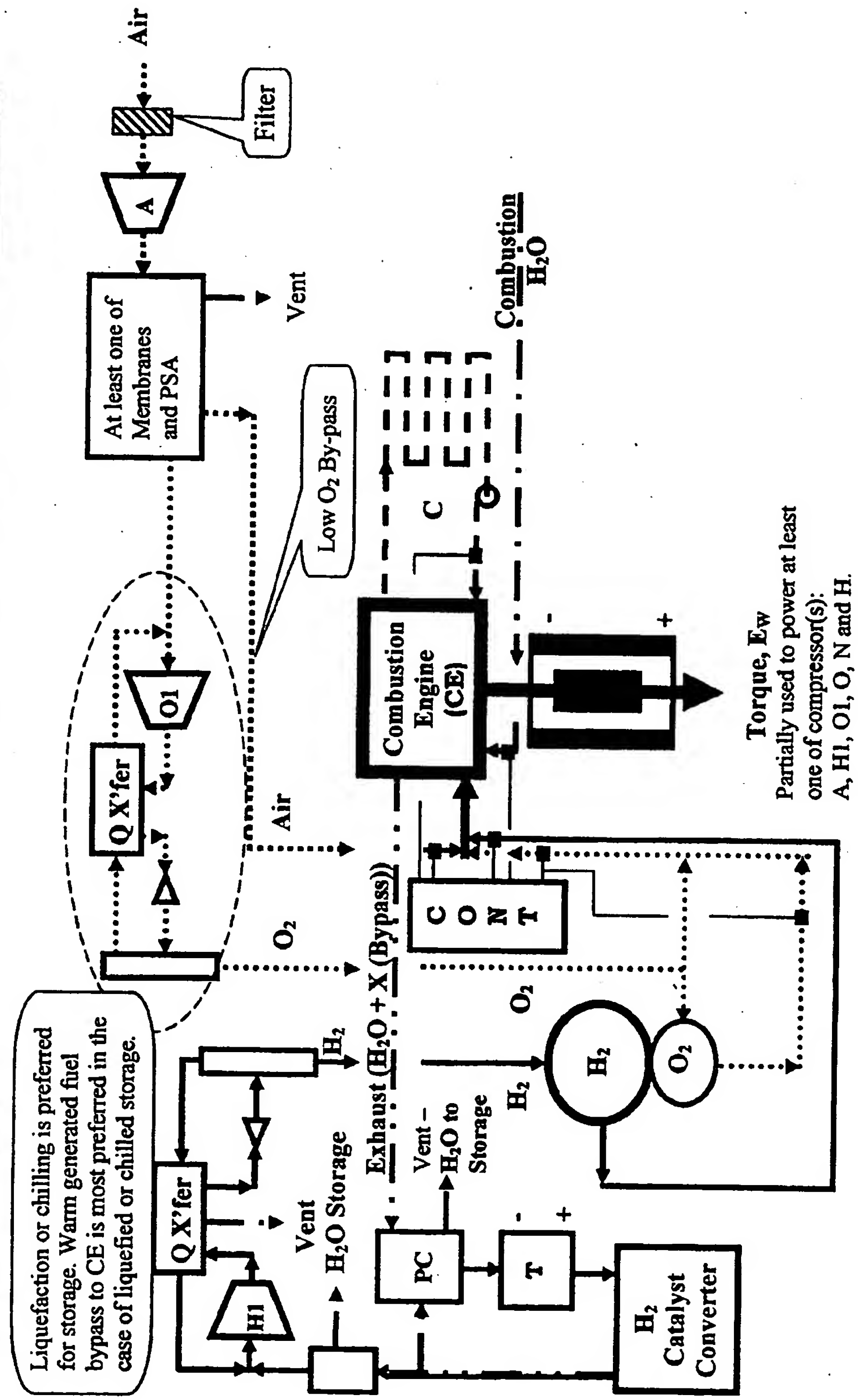


**Figure 19**

**Combustion Fueled by $H_2$ and $O_2$ and/or Air - Fuel Preheating**

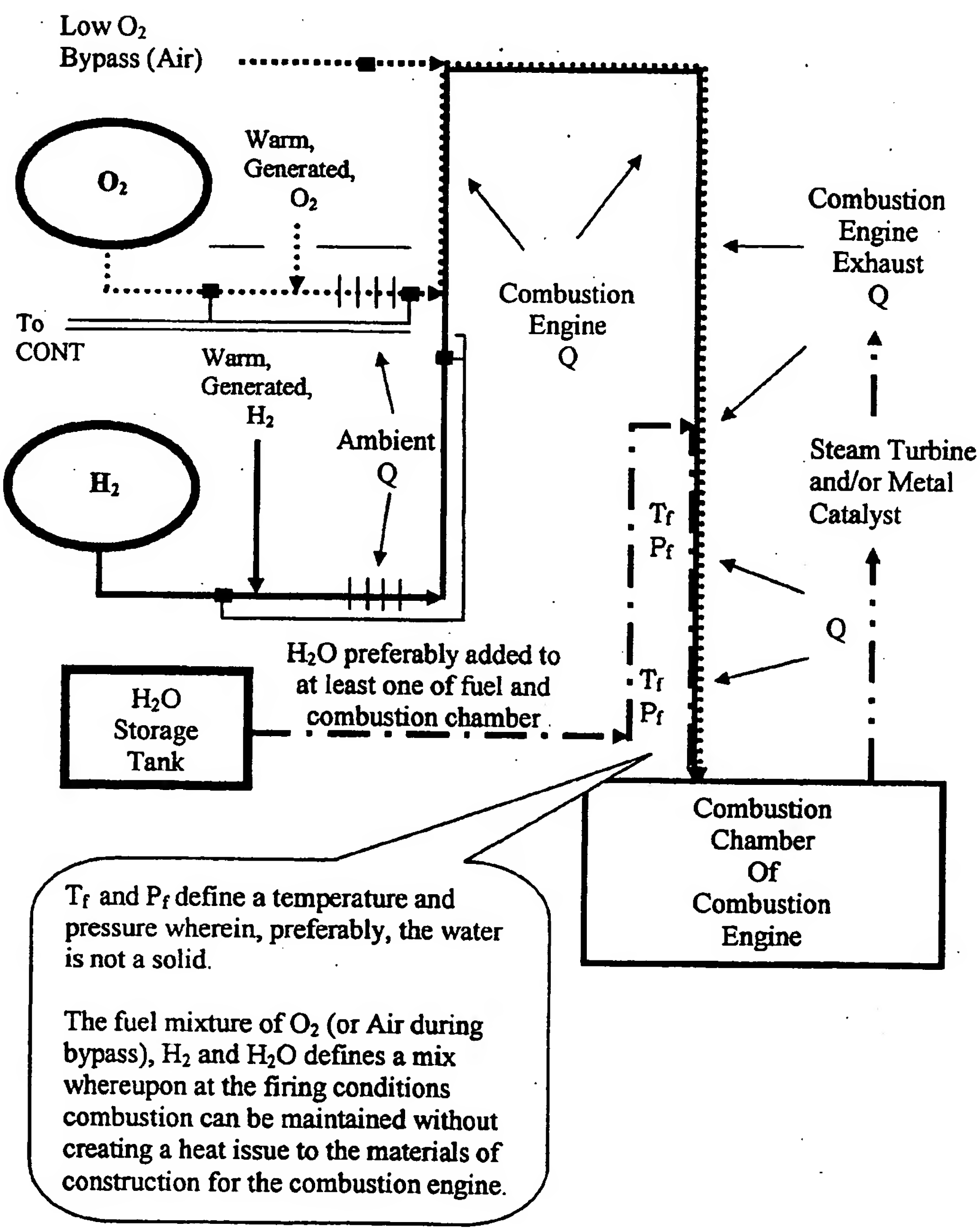


Figure 20

Combustion Fueled by $H_2$ and $O_2$ and/or Air - $O_2$ and $H_2$ Storage

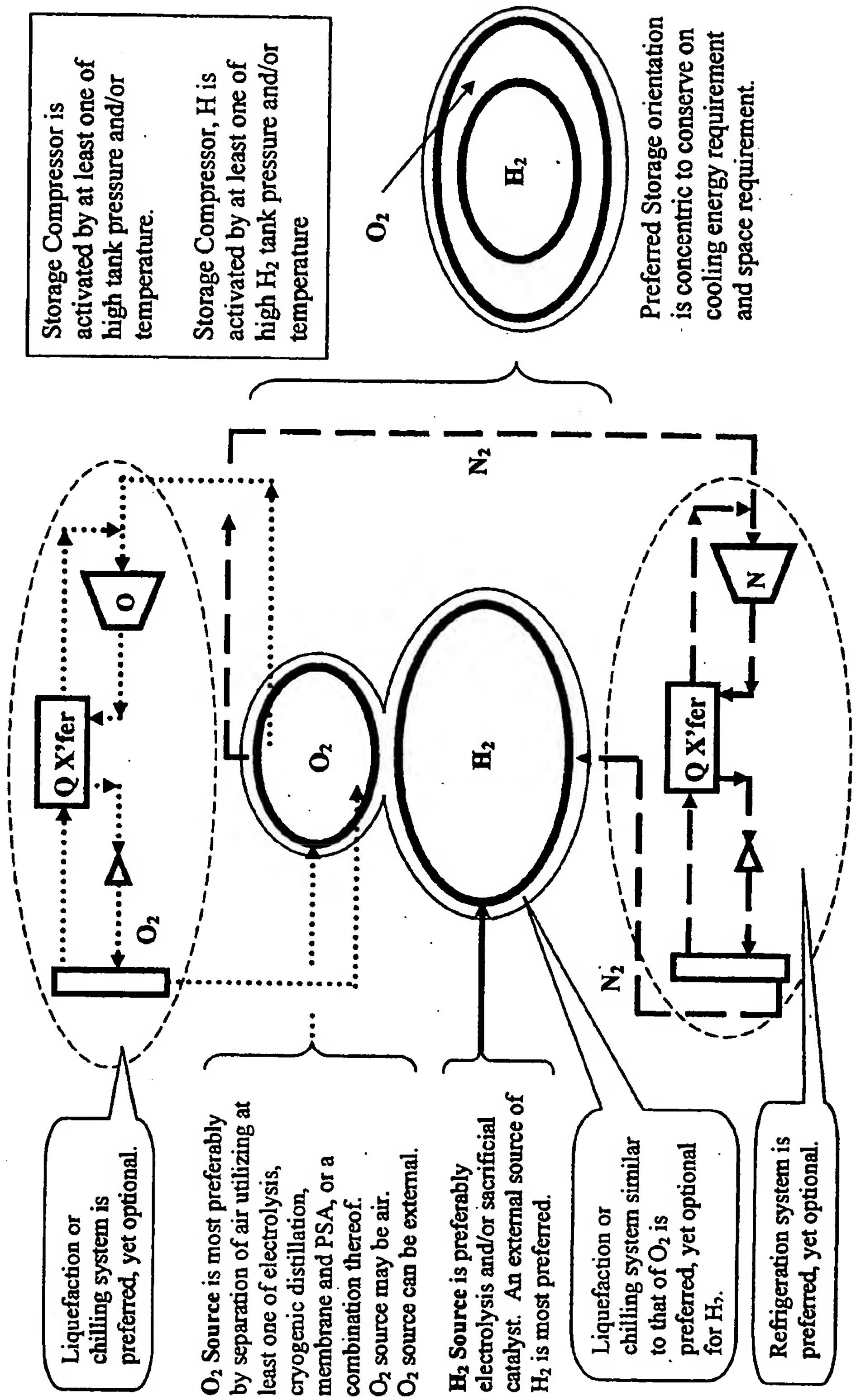
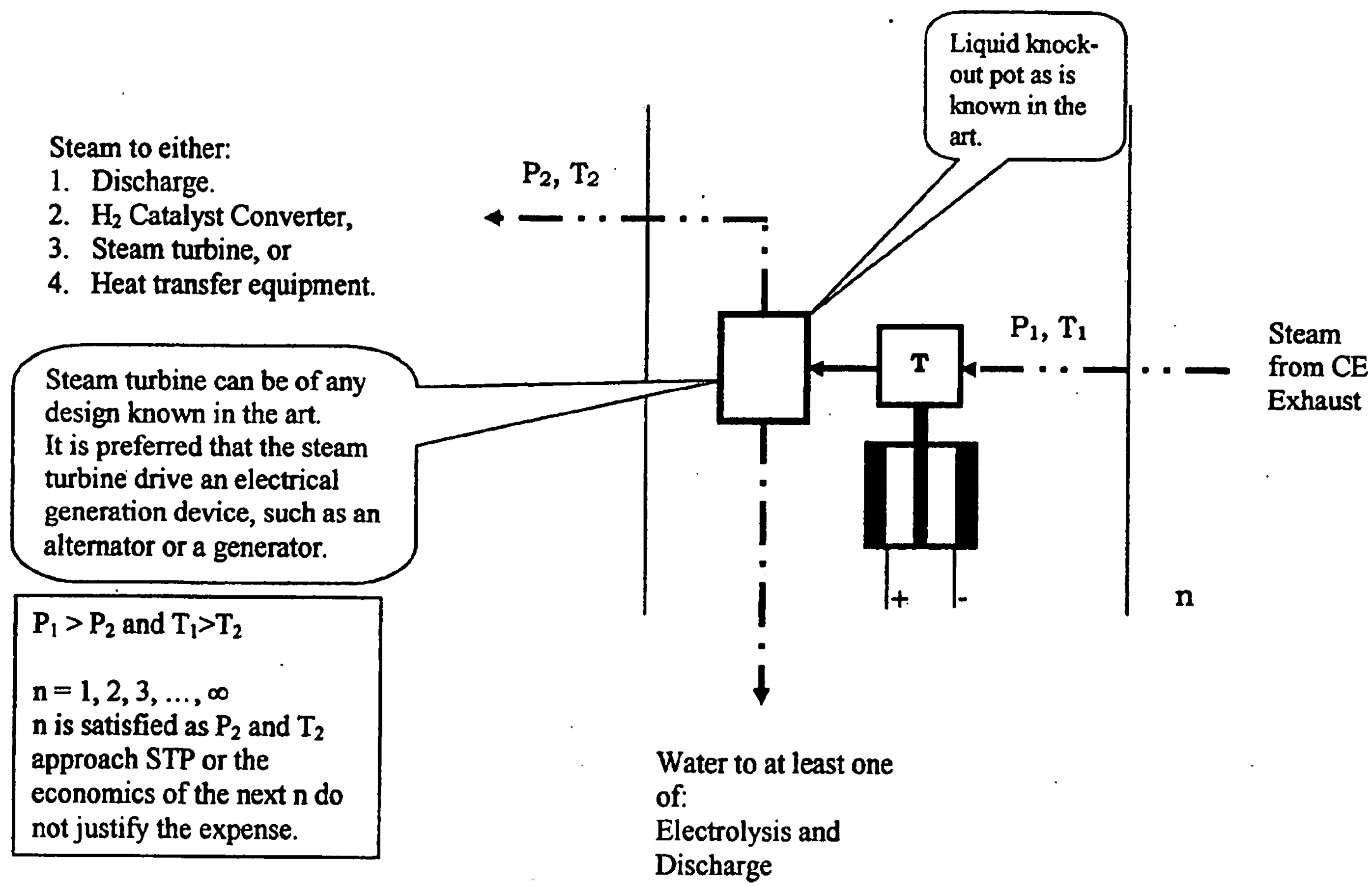


**Figure 21**
**Steam Turbine Configuration(s)**




$P_1 > P_2$ and $T_1 > T_2$

$n = 1, 2, 3, \ldots, \infty$
n is satisfied as $P_2$ and $T_2$ approach STP or the economics of the next n do not justify the expense.

Figure 21A

In-Line Combustion and Steam Turbine Configuration(s)

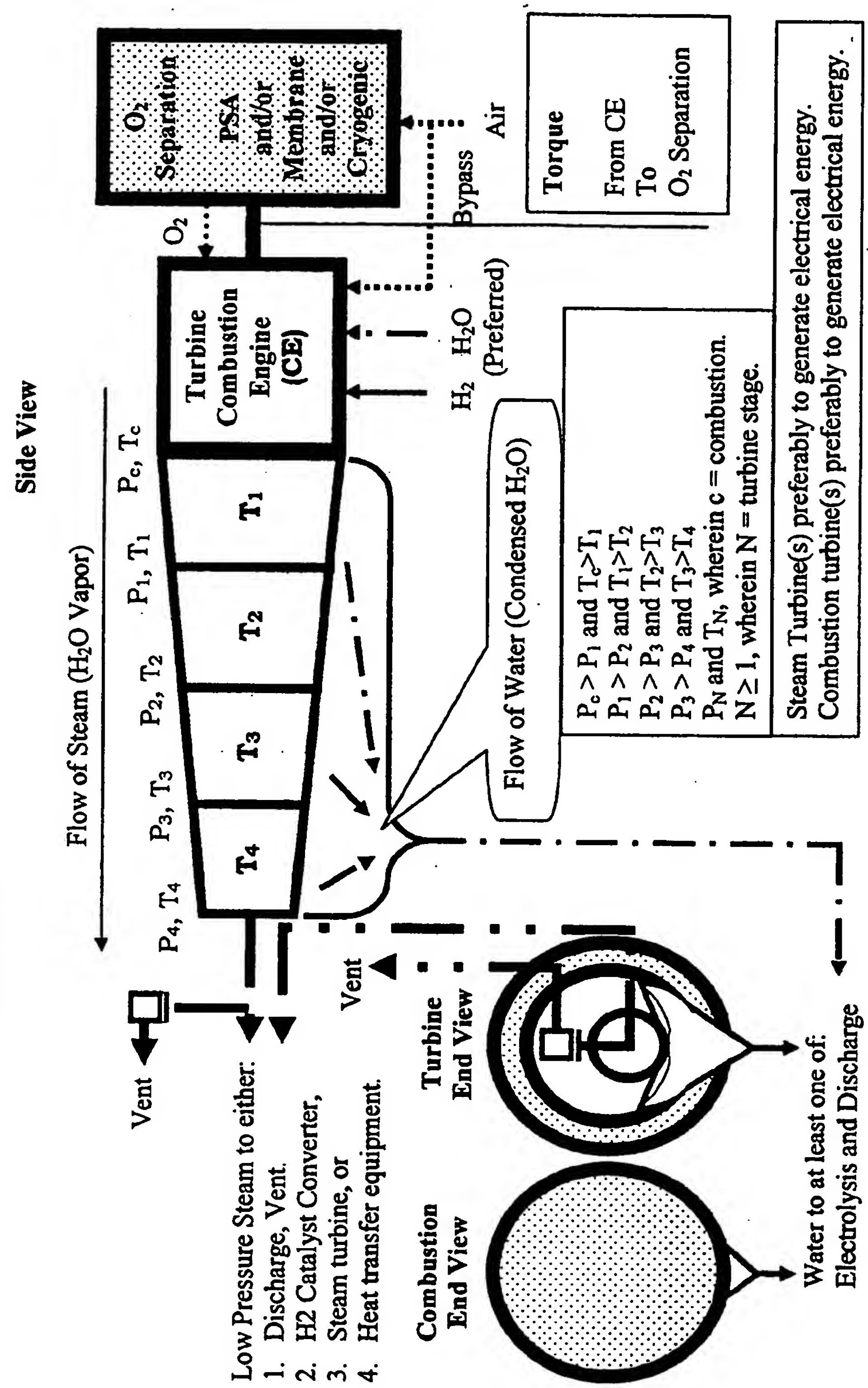


**Figure 22**
**Air Movement Turbine Configuration(s)**

$V_1 > V_2$, or $V_1 = V_2$

It is preferred that $V_1 > V_2$

$n = 1, 2, 3, \ldots, \infty$
n is satisfied as $V_2$ approaches 0 or the economics of the next n do not justify the expense or for transportation application, the drag force is too high (such would not be the case for a sail boat).

Air to at least one of:
1. Discharge.
2. Filter and Distillation,
3. Filter and PSA, or
4. Filter and membrane.

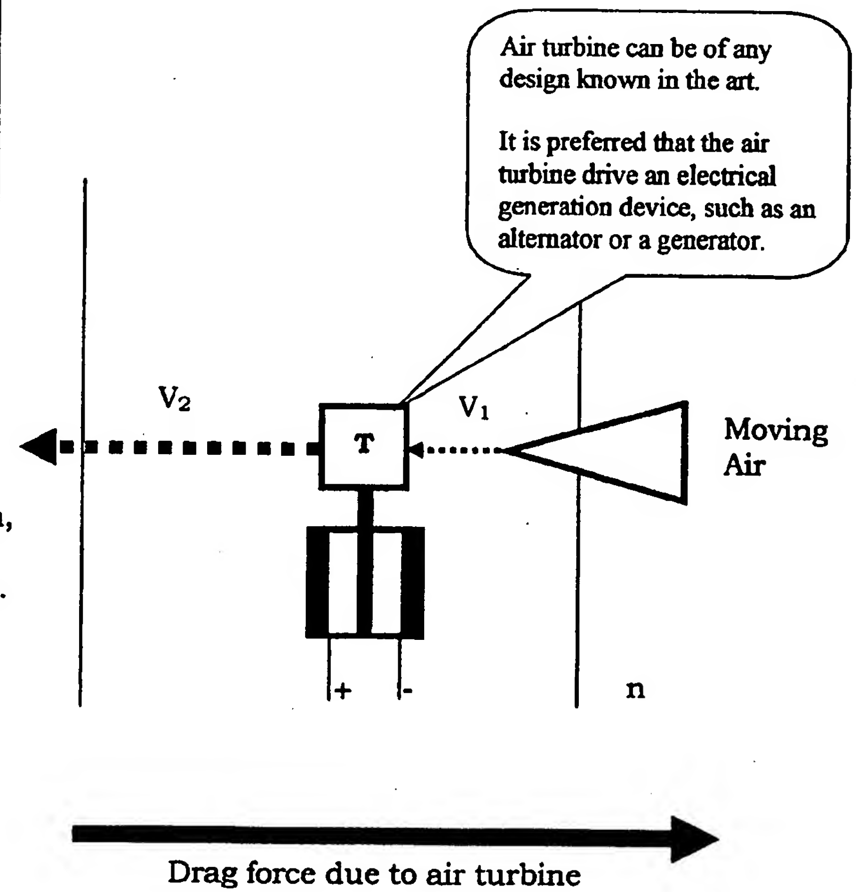


**Figure 23**
**Horizontal Water Movement Turbine Configuration(s)**

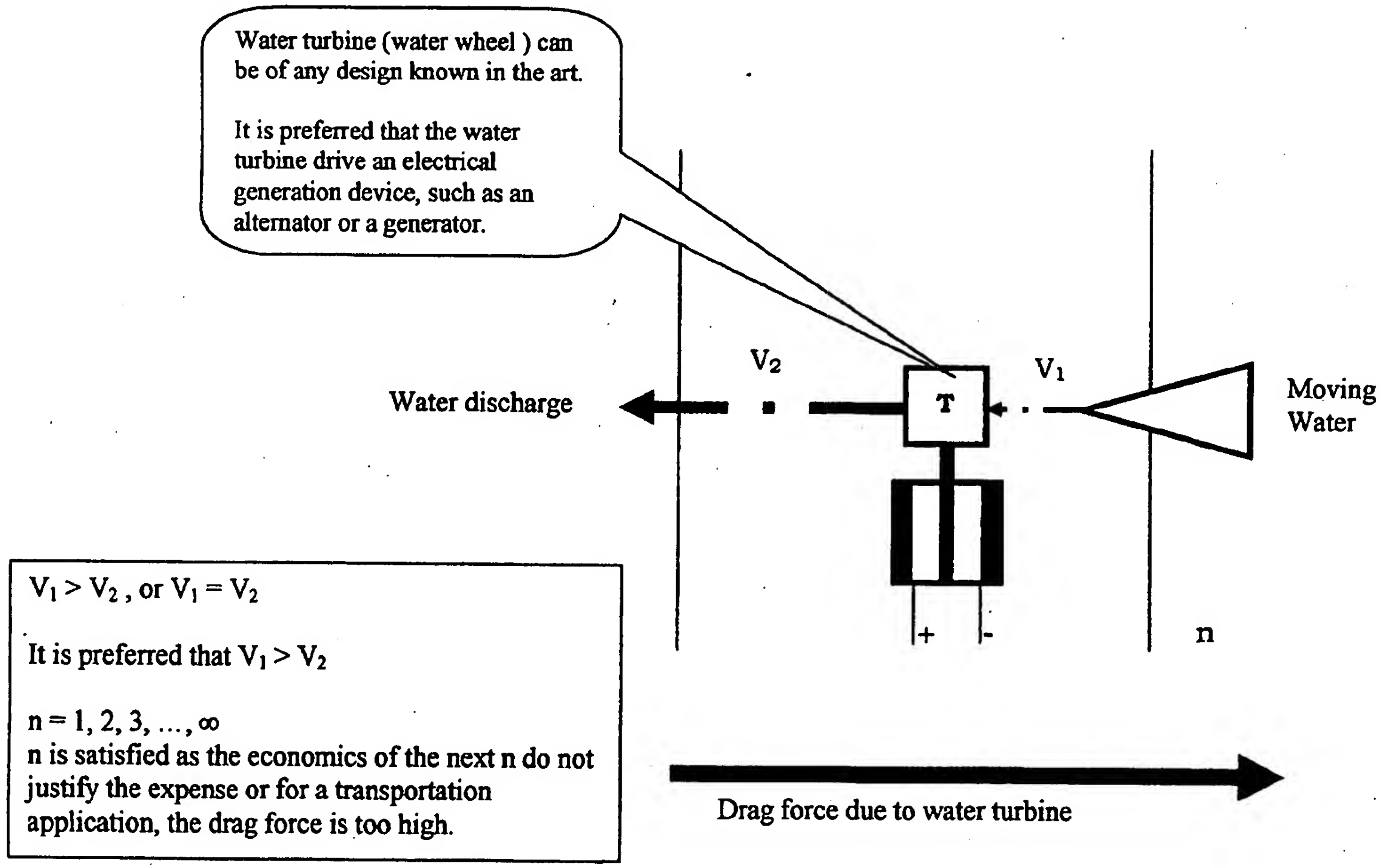


**Figure 23A**

**Vertical Water Movement Turbine Configuration(s)**

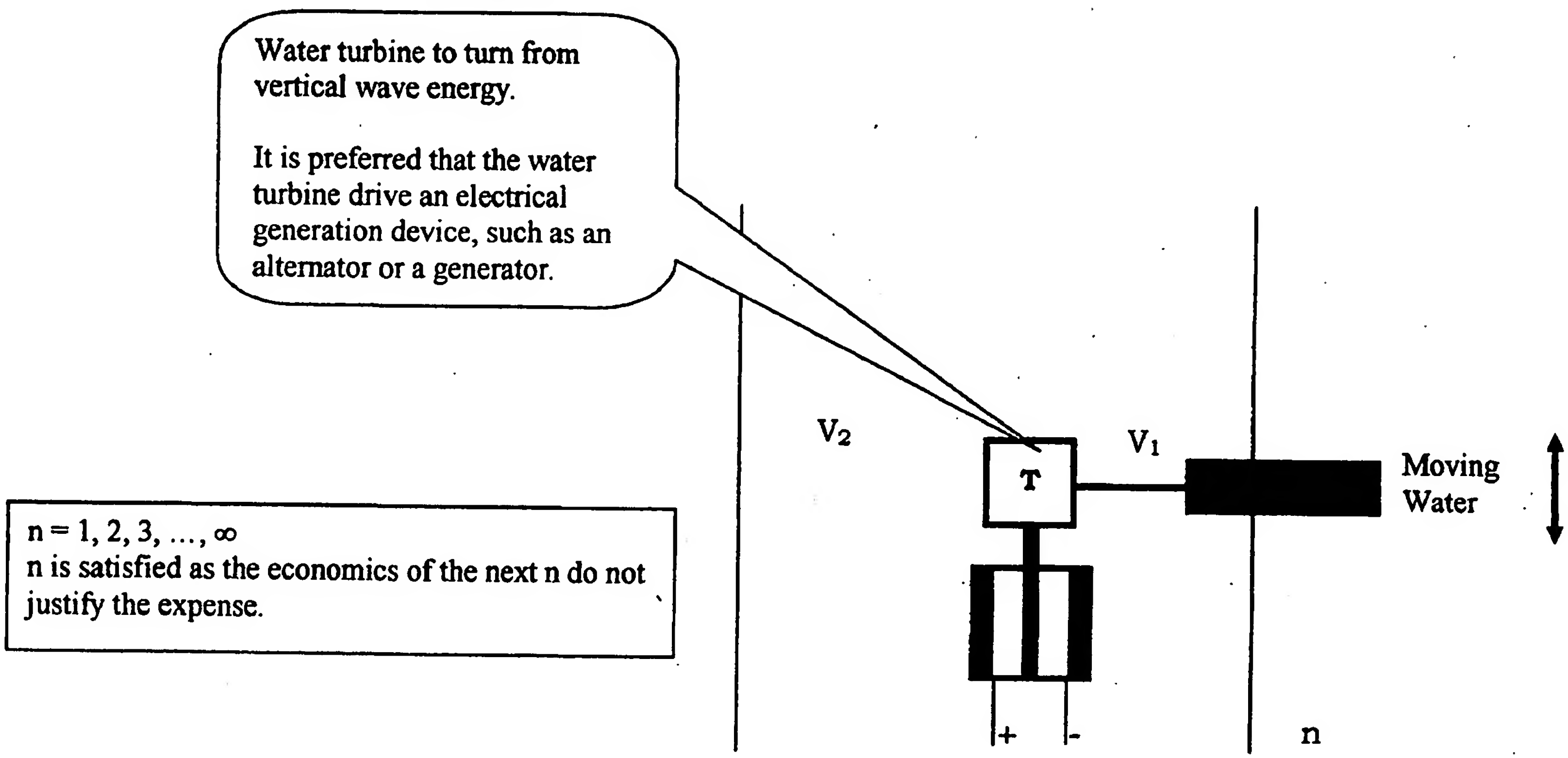
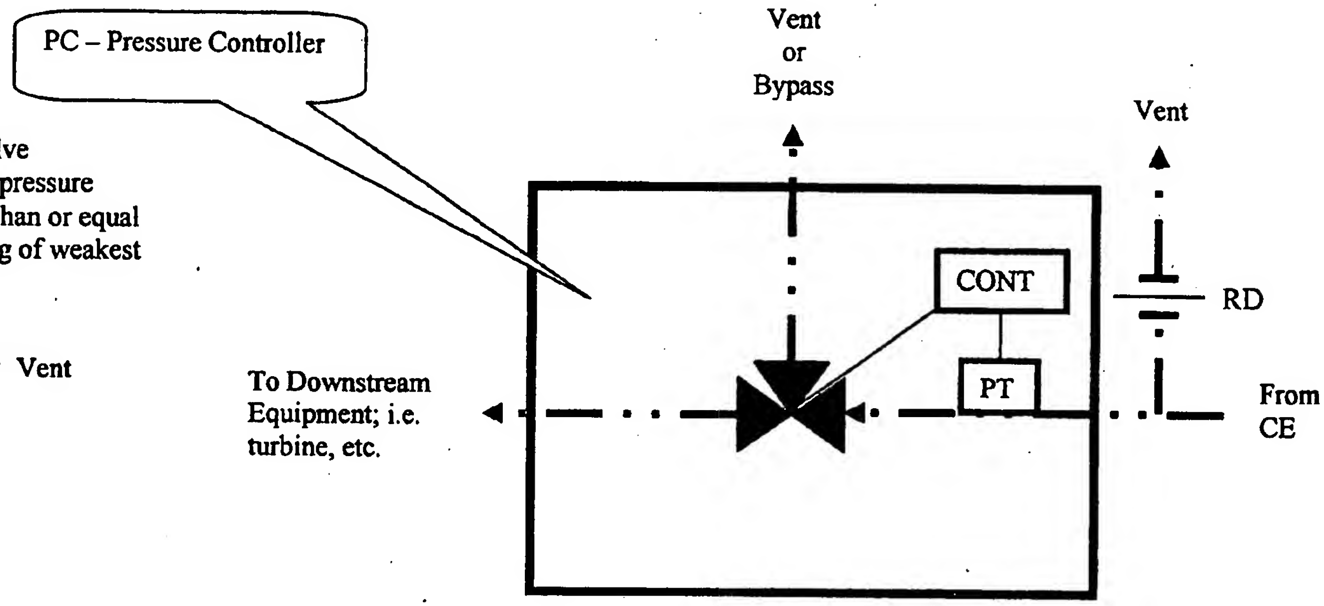
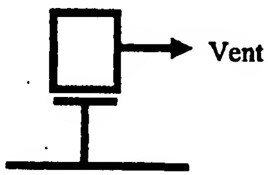
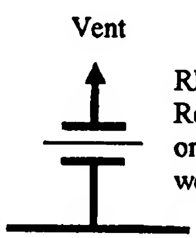


**Figure 24**
**Pressure Control Configuration(s)**




RV = Relief Valve
Relief valve set pressure
pressure is less than or equal
to pressure rating of weakest
component.




RD = Rupture Disc
Relief Pressure is less than
or equal to pressure rating of
weakest component.

Rupture disc and/or relief valve(s) located downstream of each compressor and the combustion engine.
Vent is the tail pipe or exhaust pipe for the engine.
In case of a fire, RD or RV preferred on fuel storage tanks.
Due to MW, density and flammability of fuel, vent(s) is preferred near top or behind CE.

# WATER COMBUSTION TECHNOLOGY - METHODS, PROCESSES, SYSTEMS AND APPARATUS FOR THE COMBUSTION OF HYDROGEN AND OXYGEN

## RELATED APPLICATION DATA

[0001] This application is a continuation of PCT/US 03/11250 filed Apr. 10, 2003; this continuation claims priority of PCT/US 03/11250 filed Apr. 10, 2003, of PCT/US 03/41719 filed Feb. 14, 2003; of U.S. Provisional Patent Application Ser. No. 60/371,768 filed Apr. 11, 2002, of U.S. Provisional Patent Application Ser. No. 60/379,587 filed May 10, 2002 and of U.S. Provisional Patent Application Ser. No. 60/404,644 filed Aug. 19, 2002 and of U.S. Provisional Patent Application Ser. No. 60/447,880 filed Feb. 14, 2003.

## BACKGROUND OF THE INVENTION

### Field of the Invention

[0002] This invention relates to improved combustion methods, processes, systems and apparatus, which provide environmentally friendly combustion products, as well as to fuel and energy management methods, processes, systems and apparatus for said improved combustion methods, processes, systems and apparatus. The combustion and/or fuel and/or energy management methods, processes, systems or apparatus (Water Combustion Technology, WCT) is based upon the chemistry of Water ($H_2O$), incorporating Hydrogen ($H_2$) and Oxygen ($O_2$) as fuel, as well as $H_2O$ and/or air as at least one of a heat sink and/or a fuel source. The WCT does not use a hydrocarbon as a fuel source, rather the WCT uses $H_2$ in combination preferably with $O_2$ a secondarily with air. The primary product of the combustion of $H_2$ and $O_2$ is $H_2O$. Further, in many embodiments the WCT separates $H_2O$ into $H_2$ and $O_2$, thereby making $H_2O$ an efficient method of storing fuel.

[0003] As used herein, the term combustion can incorporate any combustion method, system, process or apparatus, such a furnace, a combustion engine, an internal combustion engine, a turbine or any combustion system wherein mechanical, electrical or heat energy (heat energy can include thrust energy) is created. The discovered WCT contain embodiments wherein nitrogen ($N_2$) or $N_2$ and Argon (Ar) is partially or totally removed from the fuel mixture to improve the energy output of combustion and/or reduce the pollution output of combustion.

[0004] The discovered WCT relate to improved methods, processes, systems and apparatus for combustion that significantly improve the thermodynamics of combustion, thereby significantly improving the efficiency of combustion. Further, the discovered WCT relate to improved methods, processes, systems and apparatus for combustion wherein $H_2O$ is added to the fuel mixture to control the combustion temperature, thereby utilizing $H_2O$ during combustion as a heat sink. The WCT incorporate embodiments wherein steam produced by combustion and/or the cooling of combustion: 1) maintains the power output of combustion, 2) provides method(s) of energy transfer and 3) provides an efficient method of energy recycle. Steam presents a reusable energy source in the exhaust, both from the available kinetic and the available heat energy, as well as the conversion of said steam into $H_2$ and/or $O_2$.

[0005] Incorporating $H_2O$ into the fuel mixture with the intent of minimizing or excluding $N_2$, or $N_2$ and Ar from the fuel mixture culminates in a fuel mixture that is/are at least one of: $O_2$, $H_2$ and $H_2O$; $O_2$, $H_2$, $H_2O$ and $N_2$; $O_2$, $H_2$, $H_2O$, $N_2$ and Ar; $O_2$, $H_2$, $H_2O$ and air; $H_2$, $H_2O$ and air; and $H_2$ with excess air wherein said excess air is used to control combustion temperature. As used herein, the fuel mixture in the WCT is defined to incorporate either: $O_2$ and $H_2$; $O_2$, $H_2$ and $N_2$; $O_2$, $H_2$ and Ar; $O_2$, $H_2$ and air; $O_2$, $H_2$ and $H_2O$; $O_2$, $H_2$, $H_2O$ and $N_2$; $H_2$, $H_2O$, $N_2$ and Ar; $O_2$, $H_2$, $H_2O$ and air; $H_2$, $H_2O$ and air; or $H_2$ and excess air.

[0006] The discovered WCT relate to methods, processes, systems and apparatus of generating electricity. Four methods, processes, systems and apparatus of generating electricity are discovered. The first places a steam turbine in the exhaust of the combustion engine, wherein said steam turbine is driven by said steam produced in combustion; said steam turbine turning a generator (the term generator is used herein to define either an alternator or a dynamo), wherein at least a portion of said steam energy is converted into said electrical energy. The second places a generator on the mechanical energy output of a combustion engine, wherein at least a portion of said mechanical energy is converted by said generator into electrical energy. The third incorporates a physical system of focusing air and/or water currents onto a generator or dynamo, wherein said generator or dynamo is driven by said moving air or water to generate electrical energy. The fourth uses a photovoltaic cell to generate electrical energy.

[0007] It is discovered to use at least a portion of said electrical energy for the electrolytic generation of $H_2O$ into $O_2$ and $H_2$. If a dynamo is used, at least a portion of the dynamo D/C current is used for electrolysis; if an alternator is used an A/C to D/C converter preferably converts at least a portion of the alternating current into direct current for electrolysis. It is further discovered and preferred to utilize at least one of said electrolysis generated $O_2$ and/or $H_2$ as fuel in the WCT.

[0008] The discovered WCT further relate to methods, processes, systems and apparatus for separating $O_2$ from air. Three are discovered. By the first, $O_2$ is separated utilizing energy available from said WCT to power a cryogenic distillation system, wherein air is chilled and distilled into $O_2$ and $N_2$. By the second, air is separated producing $O_2$ utilizing membranes; said membranes can be of either organic (polymer) construction or of inorganic (ceramic) construction. By the third, air is separated producing $O_2$ utilizing Pressure Swing Adsorption (PSA). While the separation of air into $O_2$ and $N_2$ can have many degrees of separation efficiency, it is to be understood that the term $O_2$ as used herein is to mean at least enriched $O_2$, wherein the $O_2$ concentration is at least 40 percent; preferably pure $O_2$, wherein the $O_2$ concentration is at least 80 percent; and most preferably very pure $O_2$, wherein the $O_2$ concentration is at least 90 percent.

[0009] The discovered WCT further relate to methods, processes, systems and apparatus of metal catalysis, wherein said steam produced in the WCT is converted into $H_2$ and metal oxides, as part of a catalyst system. It is further discovered and preferred that at least a portion of said $H_2$ be used as a fuel in the WCT. As used herein, the term metal catalysis is to mean any metal or combination of metals in

the periodic table, wherein the metal or combination of metals will convert the $H_2O$ within steam or water vapor into the corresponding metal oxide(s) and $H_2$.

## BACKGROUND OF THE INVENTION

[0010] Mankind, has over the centuries, provided many forms of energy and many forms of transportation. In the modern capitalistic economy, the availability of energy is important to literally "fuel" the economic engine, which heats homes, provides electricity, powers lights, powers transportation and powers manufacturing facilities, etc. The availability of energy is especially important in the transportation of goods and people. During the 19'th and 20'th centuries mankind developed fossil fuels into reliable and inexpensive fuels for many uses including transportation, powering factories, generating electricity and generating heat. During the 20'th century, the use of fossil fuels increased to such an extent as to cause the combustion products of fossil fuels to be a major source of air and water pollution.

[0011] It must be understood and appreciated that most fossil fuel combustion systems have an efficiency that is less than 40 percent and that the internal combustion engine has an efficiency of less than 20 percent. These very poor results are a direct consequence of the thermodynamics of combustion. Current combustion systems significantly increase entropy, releasing entropy as well as enthalpy, to their surroundings. This is because it is very difficult for fossil fuel combustion systems to manage temperature without significant entropy and enthalpy losses to their environment; these losses are exhibited as exhaust gases and heat losses to the environment. In summary, the first and second laws of thermodynamics are a liability to fossil fuel combustion systems.

[0012] Hydrocarbon(s) have been used in combination with air as fuel for combustion. The hydrocarbons utilized have been petroleum distillates such as gasoline, diesel, fuel oil, jet fuel and kerosene, or fermentation distillates such as methanol and ethanol, or naturally occurring substances such as methane, ethane, propane, butane, coal and wood. The combustion of fossil fuel(s) does not work in concert with nature. The products of fossil fuels were thought to work in concert with nature's oxygen-carbon cycle.

$$C_nH_{2n+2} + (1.5n+1/2)O_2 \longrightarrow nCO_2 + (n+1)H_2O + \text{Energy}$$

[0013] More specifically:

$$\text{gasoline (n-Octane) } C_8H_{18} + 12\text{-}1/2O_2 \longrightarrow 8CO_2 + 9H_2O + 1{,}300\ \text{kcal}$$

$$\text{natural gas(methane) } CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O + 213\ \text{kcal}$$

[0014] Oxides of carbon ($CO_x$, CO and/or $CO_2$) are produced by the combustion of fossil fuels. This production in combination with significant deforestation has left plant life incapable of converting enough of the manmade $CO_2$ back into $O_2$. CO, an incomplete combustion by-product, is toxic to all human, animal and plant life. Global warming is a result of a buildup of $CO_X$ in the Earth's atmosphere. The combustion of air also creates oxides of Nitrogen (N), converting a portion of the $N_2$ to $NO_X$ (NO, $NO_2$ and/or $NO_3$). $NO_X$ is toxic to all human, animal and plant life. $NO_X$ is known to inhibit photosynthesis, which is nature's biochemical pathway of converting $CO_2$ back into $O_2$. The formation of $NO_X$ is endothermic, thereby lessening combustion efficiency. Further, $NO_X$ reacts with $O_2$ in the atmosphere to produce ozone ($O_3$). $O_3$ is toxic to all human, animal and plant life. $O_3$ should only exist in higher levels of the atmosphere, wherein $O_3$ is naturally created from $O_2$. In the higher levels of the atmosphere $O_3$ protects all human, animal and plant life from the harmful rays of the sun. Lastly, liquid and solid fossil fuels naturally contain sulfur (S) as a contaminant. In combustion, S is oxidized to $SO_X$ ($SO_2$, $SO_3$ and/or $SO_4$). $SO_X$ are toxic to all human, animal and plant life. $CO_X$, $NO_X$ and $SO_X$ react with water in the air to form acids of $CO_X$, $NO_X$ and/or $SO_X$, which literally rain acids upon the earth. In summary, $CO_X$, $NO_X$, $SO_X$ and $O_3$ in the air adversely affect the health of all human, animal and plant life. An environmentally acceptable alternative to fossil fuels would be a fuel system that does work in concert with nature. Such a system would not produce $CO_X$, $NO_X$ or $SO_X$, and thereby not generate $O_3$.

[0015] There has been much done mechanically and chemically to combat the environmental issues associated with hydrocarbon combustion. As an example, industrial facilities are outfitted with expensive scrubber systems whenever the politics demand the installation and/or the business supports the installation. As another example, the internal combustion engine has been enhanced significantly to make the engine more fuel efficient and environmentally friendly. Even with enhancement, the internal combustion engine is only approximately 20 percent efficient and the gas turbine/steam turbine system is only approximately 30 to 40 percent efficient. As depicted in **FIG. 2**, the internal combustion engine looses as a percentage of available energy fuel value: 1) approximately 35 percent in the exhaust, 2) approximately 35 percent in cooling, 3) approximately 9 percent in friction, and 4) only 1 percent due to poor combustion performance, leaving the engine approximately 20 percent efficient.

[0016] Hydrocarbon fuels have been modified with additives to minimize the formation of either $CO_X$ or $NO_X$. However, with all of the scrubber modifications, engine modifications and fuel modifications, the Earth is struggling to deal with manmade pollutants that originate from hydrocarbon combustion systems. In addition to the environmental issues, availability and dependability of large quantities of petroleum hydrocarbons has become a geopolitical issue.

[0017] There have been many previous attempts to produce a combustion engine that would operate on air and $H_2$. Those attempts had as difficulties: the high temperature of combustion, increased $NO_X$ formation at higher combustion temperatures, storage capacity for large enough quantities of $H_2$ and cost of operation. Jet propulsion applications had as difficulties: high combustion temperatures, lack of available thrust and a lower altitude propulsion limit than kerosene. As compared to hydrocarbons, the combustion of $H_2$ occurs with $H_2$ having three times the available combustion energy per pound; in addition $H_2$ is much less dense than hydro-

carbons, this density difference is significant in both in the available gas and in the cryogenically stored liquid form. $H_2$ is a gas at atmospheric pressure. $H_2$ is not a liquid until the temperature is lowered to near −430° F.; therefore, storage equipment for $H_2$ need to either be able to withstand high pressure, cryogenic temperatures or both. Such storage equipment for large volumes of $H_2$ becomes economically impractical.

[0018] Historically and currently it has been believed that the electric motor is the solution to finding an environmentally friendly energy source. However, this concept has deficiencies in that the electrical energy required to power an electric motor must be created and stored. Electrical energy is created with either: 1) hydrocarbon combustion/steam generation processes, 2) photovoltaic generation processes, 3) water driven generation processes, 4) windmill driven generation processes or 5) nuclear generation/steam driven generation processes. While the photovoltaic process is environmentally friendly, the photovoltaic process is not reliable or effective enough in many applications to replace the combustion engine. While the water driven (water wheel) generation process is environmentally friendly, the water driven generation process is a geographically limited energy source. While the windmill driven generation process is environmentally friendly, wind is a limited non-reliable resource. While the nuclear generation/steam driven generation process is environmentally friendly, concerns over the safety of such installations have limited applications.

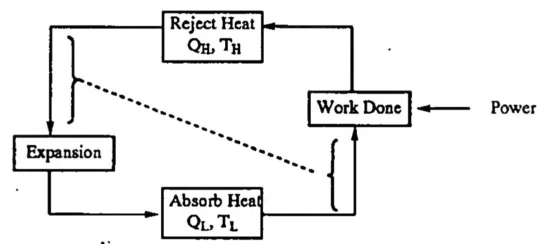
[0019] Commercialization of the electric car has been limited due to electrical energy cost and the electrical energy mass storage requirement being so massive that under the best of circumstances the electric car must be limited to short distances or supplemented with an internal combustion engine.

[0020] Previous and current attempts to produce a fuel cell that would operate on $H_2$ and air, as well as hydrocarbons and air are showing promising results. However, the capital investment to power output ratio for fuel cells is 400 to 500 percent of that same investment for traditional combustion systems. Also, the required maintenance of fuel cells increases the cost of operation. In addition, fuel cells require Platinum; there is not enough Platinum in the Earth's crust for one year's automotive production, much less enough for the energy needs of the world. Lastly, in transportation the fuel cell does not have the same "feel" as the internal combustion engine, which may lead to acceptance challenges. Previous attempts to replace or reduce the power of the internal combustion engine have failed due to market acceptance. Auto enthusiasts have come to enjoy and expect the "feel" and power of the internal combustion engine.

[0021] Previous work to develop a combustion engine that would operate on fuel(s) other than hydrocarbon(s) can be referenced in U.S. Pat. No. 3,884,262, U.S. Pat. No. 3,982,878, U.S. Pat. No. 4,167,919, U.S. Pat. No. 4,308,844, U.S. Pat. No. 4,599,865 U.S. Pat. No. 5,775,091, U.S. Pat. No. 5,293,857, U.S. Pat. No. 5,782,081, U.S. Pat. No. 5,775,091 and U.S. Pat. No. 6,290,184. The closest work is U.S. Pat. No. 6,289,666 B1. While each of these patents present improvements in combustion technology, each leaves issues that have left the commercialization of such a combustion engine impractical.

[0022] While there are many methods to prepare $O_2$, the separation of air into its component gases is industrially performed by three methods: cryogenic distillation, membrane separation and PSA.

[0023] There are many methods and processes utilized for cryogenic refrigeration, which is a component of cryogenic distillation. A good reference of cryogenic refrigeration methods and processes known in the art would be "Cryogenic Engineering," written by Thomas M. Flynn and printed by Dekker. As written by Flynn, cryogenic refrigeration and liquefaction are the same processes, except liquefaction takes off a portion of the refrigerated liquid which must be made up, wherein refrigeration all of the liquid is recycled. All of the methods and processes of refrigeration and liquefaction are based upon the same basic refrigeration principals, as depicted in Flow Diagram 1.




Flow Diagram 1

[0024] As written by Flynn, there are many ways to combine the few components of work (compression), rejecting heat, expansion and absorbing heat. There exist in the art many methods and processes of cryogenic refrigeration, all of which can be adapted for cryogenic liquefaction. A listing of those refrigeration cycles would include: Joule Thompson, Stirling, Brayton, Claude, Linde, Hampson, Postle, Ericsson, Gifford-McMahon and Vuilleumier. As written by Flynn, "There are as many ways to combine these few components as there are engineers to combine them." (It is important to note, as is known in the art, that $H_2$ has a negative Joule-Thompson coefficient until temperatures of approximately 350 R are obtained.)

[0025] Conventional cryogenic air distillation processes that separate air into $O_2$, Ar and $N_2$ are commonly based on a dual pressure cycle. Air is first compressed and subsequently cooled. Cooling may be accomplished by one of four methods: 1—Vaporization of a liquid, 2—The Joule Thompson Effect (which performs best when augmented with method 3), 3—Counter-current heat exchange with previously cooled warming product streams or with externally cooled warming product streams and 4—The expansion of a gas in an engine doing external work. The cooled and compressed air is usually introduced into two fractionating zones. The first fractionating zone is thermally linked with a second fractionating zone which is at a lower pressure. The two zones are thermally linked such that a condenser of the first zone reboils the second zone. The air undergoes a partial distillation in the first zone producing a substantially pure $N_2$ fraction and a liquid fraction that is enriched in $O_2$. The enriched $O_2$ fraction is an intermediate feed to the second fractionating zone. The substantially pure

liquid $N_2$ from the first fractionating zone is used as reflux at the top of the second fractionating zone. In the second fractionating zone separation is completed, producing substantially pure $O_2$ from the bottom of the zone and substantially pure $N_2$ from the top. When Ar is produced in the conventional process, a third fractionating zone is employed. The feed to this zone is a vapor fraction enriched in Ar which is withdrawn from an intermediate point in the second fractionating zone. The pressure of this third zone is of the same order as that of the second zone. In the third fractionating zone, the feed is rectified into an Ar rich stream which is withdrawn from the top, and a liquid stream which is withdrawn from the bottom of the third fractionating zone and introduced to the second fractionating zone at an intermediate point. Reflux for the third fractionating zone is provided by a condenser which is located at the top. In this condenser, Ar enriched vapor is condensed by heat exchange from another stream, which is typically the enriched $O_2$ fraction from the first fractionating zone. The enriched $O_2$ stream then enters the second fractionating zone in a partially vaporized state at an intermediate point, above the point where the feed to third fractionating zone is withdrawn.

[0026] The distillation of air, a ternary mixture, into $N_2$, $O_2$ and Ar may be viewed as two binary distillations. One binary distillation is the separation of the high boiling point $O_2$ from the intermediate boiling point Ar. The other binary distillation is the separation of the intermediate boiling point Ar from the low boiling point $N_2$. Of these two binary distillations, the former is more difficult, requiring more reflux and/or theoretical trays than the latter. Ar—$O_2$ separation is the primary function of third fractionating zone and the bottom section of the second fractionating zone below the point where the feed to the third zone is withdrawn. $N_2$—Ar separation is the primary function of the upper section of the second fractionating zone above the point where the feed to the third fractionating zone is withdrawn.

[0027] The ease of distillation is also a function of pressure. Both binary separations become more difficult at higher pressure. This fact dictates that for the conventional arrangement the optimal operating pressure of the second and third fractionating zones is at or near the minimal pressure of one atmosphere. For the conventional arrangement, product recoveries decrease substantially as the operating pressure is increased above one atmosphere mainly due to the increasing difficulty of the Ar—$O_2$ separation. There are other considerations, however, which make elevated pressure processing attractive. Distillation column diameters and heat exchanger cross sectional areas can be decreased due to increased vapor density. Elevated pressure products can provide substantial compression equipment capital cost savings. In some cases, integration of the air separation process with a power generating gas turbine is desired. In these cases, elevated pressure operation of the air separation process is required. The air feed to the first fractionating zone is at an elevated pressure of approximately 10 to 20 atmospheres absolute. This causes the operating pressure of the second and third fractionating zones to be approximately 3 to 6 atmospheres absolute. Operation of the conventional arrangement at these pressures results in very poor product recoveries due to the previously described effect of pressure on the ease of separation.

[0028] As used herein: the term "indirect heat exchange" means the bringing of two fluid streams into heat exchange relation without any physical contact or intermixing of the fluids with each other; the term "air" means a mixture comprising primarily $N_2$, $O_2$ and Ar; the terms "upper portion" and "lower portion" mean those sections of a column respectively above and below the midpoint of the column; the term "tray" means a contacting stage, which is not necessarily an equilibrium stage, and may mean other contacting apparatus such as packing having a separation capability equivalent to one tray; the term "equilibrium stage" means a vapor-liquid contacting stage whereby the vapor and liquid leaving the stage are in mass transfer equilibrium, e.g. a tray having 100 percent efficiency or a packing element height equivalent to one theoretical plate (HETP); the term "top condenser" means a heat exchange device which generates column downflow liquid from column top vapor; the term "bottom reboiler" means a heat exchange device which generates column upflow vapor from column bottom liquid. (A bottom reboiler may be physically within or outside a column. When the bottom reboiler is within a column, the bottom reboiler encompasses the portion of the column below the lowermost tray or equilibrium stage of the column.)

[0029] While it is well known in the chemical industry that the cryogenic distillation of air into $O_2$ and $N_2$ is the most economical pathway to produce these elemental diatomic gases, it has not been proposed to utilize this industrial process to either: distill $H_2$ along with $O_2$ and $N_2$, fuel the combustion of $O_2$ with $H_2$ with $O_2$ from cryogenic distillation and/or utilize the energy of the combustion of $O_2$ with $H_2$ to power the cryogenic distillation of air. Previous work performed to separate air into its components can be referenced in U.S. Pat. No. 4,112,875; U.S. Pat. No. 5,245,832; U.S. Pat. No. 5,976,273; U.S. Pat. No. 6,048,509; U.S. Pat. No. 6,082,136; U.S. Pat. No. 6,298,668 and U.S. Pat. No. 6,333,445.

[0030] It is also well known in many industries to separate air with membranes. Two general types of membranes are known in the art: organic polymer membranes and inorganic membranes. These membrane separation processes are improved by setting up an electric potential across a membrane that has been designed to be electrically conductive. While many of these processes are well known and established, it has not been proposed to utilize either of these processes to fuel the combustion of $O_2$ with $H_2$ or to utilize the energy of the combustion of $O_2$ with $H_2$ to power the membrane separation of air. Previous work performed to separate air into its components with membranes can be referenced in U.S. Pat. No. 5,599,383; U.S. Pat. No. 5,820,654; U.S. Pat. No. 6,277,483; U.S. Pat. No. 6,289,884; U.S. Pat. No. 6,298,664; U.S. Pat. No. 6,315,814; U.S. Pat. No. 6,321,915; U.S. Pat. No. 6,325,218; U.S. Pat. No. 6,340,381; U.S. Pat. No. 6,357,601; U.S. Pat. No. 6,360,524; U.S. Pat. No. 6,361,582; U.S. Pat. No. 6,361,583 and U.S. Pat. No. 6,372,020.

[0031] It is also known to separate air into $O_2$ and $N_2$ with PSA. However, it has not been proposed to utilize PSA to fuel the combustion of $O_2$ with $H_2$ or to utilize the energy of the combustion of $O_2$ with $H_2$ to power PSA separation of air. Previous work performed to separate air into its components with PSA can be referenced in U.S. Pat. No. 3,140,931; U.S. Pat. No. 3,140,932; U.S. Pat. No. 3,140,933;

U.S. Pat. No. 3,313,091; U.S. Pat. No. 4,481,018; U.S. Pat. No. 4,557,736; U.S. Pat. No. 4,859,217; U.S. Pat. No. 5,464,467; U.S. Pat. No. 6,183,709 and U.S. Pat. No. 6,284,201.

[0032] The discovered WCT relate to chemical methods, processes, systems and apparatus for producing $H_2$ from steam, since steam is the physical state of the water product from the WCT. Previous work in this field has focused on refinery or power plant exhaust gases; none of that work discusses the separation of $H_2O$ back into $H_2$. Previous work performed to utilize the products of hydrocarbon combustion from an internal combustion engine can be referenced in U.S. Pat. No. 4,003,343. Previous work in corrosion is in the direction of preventing corrosion instead of encouraging corrosion, yet can be referenced in U.S. Pat. No. 6,315,876, U.S. Pat. No. 6,320,395, U.S. Pat. No. 6,331,243, U.S. Pat. No. 6,346,188, U.S. Pat. No. 6,348,143 and U.S. Pat. No. 6,358,397.

[0033] The discovered WCT relate to electrolytic methods, processes, systems and apparatus to electro-chemically convert $H_2O$ into $O_2$ and $H_2$. While there have been improvements in the technology of electrolysis and there have been many attempts to incorporate electrolysis with a combustion engine, wherein the hydrocarbon fuel is supplemented by $H_2$ produced by electrolysis, there has been no work with electrolysis to fuel a combustion engine wherein electrolysis is a significant source of $O_2$ and $H_2$. Previous work in electrolysis as electrolysis relate to combustion systems can be referenced in U.S. Pat. No. 6,336,430, U.S. Pat. No. 6,338,786, U.S. Pat. No. 6,361,893, U.S. Pat. No. 6,365,026, U.S. Pat. No. 6,635,032 and U.S. Pat. No. 4,003,035.

[0034] The discovered WCT relate to the production of electricity. The mechanical energy for a mechanically driven electrical generation device, which can be a generator or an alternator, is produced by the fuel(s) of the WCT. In addition, the steam energy for a steam driven generator is produced by the fuel(s) of the WCT; the WCT Engine exhaust steam energy may drive a steam turbine, thereby driving a generator creating an electrical current. Further, said exhaust gas, $H_2O$, minimizes environmental equipment. The discovered WCT presents a combustion turbine, wherein the exhaust gas is at least primarily if not totally $H_2O$ or $H_2O$ and air. While there has been much work in the design of steam turbines, in all cases the steam for the steam turbine is generated by heat transfer, wherein said heat for heat transfer is created by nuclear fission or hydrocarbon combustion. The concept of utilizing a steam turbine in the direct exhaust of a combustion engine or to recycle energy within a combustion engine, especially to create electricity for the electrolytic conversion of $H_2O$ into $O_2$ and $H_2$ is new and novel. Previous work in steam turbine generation technology or engine exhaust turbine technology can be referenced in: U.S. Pat. No. 6,100,600, U.S. Pat. No. 6,305,901, U.S. Pat. No. 6,332,754, U.S. Pat. No. 6,341,941, U.S. Pat. No. 6,345,952, U.S. Pat. No. 4,003,035, U.S. Pat. No. 6,298,651, U.S. Pat. No. 6,354,798, U.S. Pat. No. 6,357,235, U.S. Pat. No. 6,358,004 and U.S. Pat. No. 6,363,710, the closest being U.S. Pat. No. 4,094,148 and U.S. Pat. No. 6,286,315 B1.

[0035] The discovered WCT relate to air and water driven turbine technologies to create electricity. Air or water driven turbine electrical generation technology would be applicable to combustion system(s) utilizing the discovered WCT, wherein: there is a reliable source of moving air and/or water. While a moving source of air or a moving source of water may be an excellent source of electrical power generation to fuel the electrolysis of $H_2O$, the concept of either: the use of said electrolysis to fuel the discovered WCT or of a windmill or waterwheel to power said electrolysis in order to fuel the discovered WCT is novel. Previous work in wind driven generator technology can be referenced in U.S. Pat. No. 3,995,972, U.S. Pat. No. 4,024,409, U.S. Pat. No. 5,709,419, U.S. Pat. No. 6,132,172, U.S. Pat. No. 6,153,944, U.S. Pat. No. 6,224,338, U.S. Pat. No. 6,232,673, U.S. Pat. No. 6,239,506, U.S. Pat. No. 6,247,897, U.S. Pat. No. 6,270,308, U.S. Pat. No. 6,273,680, U.S. Pat. No. 293,835, U.S. Pat. No. 294,844, U.S. Pat. No. 6,302,652, U.S. Pat. No. 6,323,572, and U.S. Pat. No. 6,635,981.

[0036] The discovered WCT relate to photovoltaic methods, processes, systems and apparatus to create electricity, wherein said electricity is used to create at least one of $H_2$ and $O_2$, wherein said $H_2$ and/or said $O_2$ is used as a fuel in said WCT. There are many methods, processes, systems and apparatus for the photovoltaic production of electricity, as is known in the art. There are many methods, systems and processes wherein a photovoltaic cell is used to create electricity for the electrolytic separation of $H_2O$ into $H_2$ and $O_2$, wherein the $H_2$ is used in a fuel cell. Previous work in photovoltaic cells in relation to the production of $H_2$ can be referenced in: U.S. Pat. No. 5,797,997, U.S. Pat. No. 5,900,330, U.S. Pat. No. 5,986,206, U.S. Pat. No. 6,075,203, U.S. Pat. No. 6,128,903, U.S. Pat. No. 6,166,397, U.S. Pat. No. 6,172,296, U.S. Pat. No. 6,211,643, U.S. Pat. No. 6,214,636, U.S. Pat. No. 6,279,321, U.S. Pat. No. 6,372,978, U.S. Pat. No. 6,459,231, U.S. Pat. No. 6,471,834, U.S. Pat. No. 6,489,553, U.S. Pat. No. 6,503,648, U.S. Pat. No. 6,508,929, U.S. Pat. No. 6,515,219 and U.S. Pat. No. 6,515,283. None of the previous work describes or suggests the use of a photovoltaic cell in combination with said WCT.

[0037] The discovered WCT relate to methods of controlling corrosion, scale and deposition in water applications. U.S. Pat. No. 4,209,398 issued to Ii, et al., on Jun. 24, 1980 presents a process for treating water to inhibit formation of scale and deposits on surfaces in contact with the water and to minimize corrosion of the surfaces. The process comprises mixing in the water an effective amount of water soluble polymer containing a structural unit that is derived from a monomer having an ethylenically unsaturated bond and having one or more carboxyl radicals, at least a part of said carboxyl radicals being modified, and one or more corrosion inhibitor compounds selected from the group consisting of inorganic phosphoric acids and water soluble salts therefore, phosphonic acids and water soluble salts thereof, organic phosphoric acids and water soluble salts thereof, organic phosphoric acid esters and water-soluble salts thereof and polyvalent metal salts, capable of being dissociated to polyvalent metal ions in water. The Ii patent does not discuss or present systems of electrolysis or of combustion.

[0038] U.S. Pat. No. 4,442,009 issued to O'Leary, et al., on Apr. 10, 1984 presents a method for controlling scale formed from water soluble calcium, magnesium and iron impurities contained in boiler water. The method comprises adding to the water a chelant and water soluble salts thereof,

a water soluble phosphate salt and a water soluble poly methacrylic acid or water soluble salt thereof. The O'Leary patent does not discuss or present systems of electrolysis or of combustion.

[0039] U.S. Pat. No. 4,631,131 issued to Cuisia, et al., on Dec. 23, 1986 presents a method for inhibiting formation of scale in an aqueous steam generating boiler system. Said method comprises a chemical treatment consisting essentially of adding to the water in the boiler system scale-inhibiting amounts of a composition comprising a copolymer of maleic acid and alkyl sulfonic acid or a water soluble salt thereof, hydroxylethylidenel, 1-diphosphic acid or a water soluble salt thereof and a water soluble sodium phosphate hardness precipitating agent. The Cuisia patent does not discuss or present systems of electrolysis or of combustion.

[0040] U.S. Pat. No. 4,640,793 issued to Persinski, et al., on Feb. 3, 1987 presents an admixture, and its use in inhibiting scale and corrosion in aqueous systems, comprising: (a) a water soluble polymer having a weight average molecular weight of less than 25,000 comprising an unsaturated carboxylic acid and an unsaturated sulfonic acid, or their salts, having a ratio of 1:20 to 20:1, and (b) at least one compound selected from the group consisting of water soluble polycarboxylates, phosphonates, phosphates, polyphosphates, metal salts and sulfonates. The Persinski patent presents chemical combinations which prevent scale and corrosion; however, the Persinski patent does not address electrolysis or combustion.

## SUMMARY OF THE INVENTION

[0041] A primary object of the invention is to devise environmentally friendly, effective, efficient and economically feasible combustion methods, processes, systems and apparatus.

[0042] Another object of the invention is to devise environmentally friendly, effective, efficient and economically feasible combustion methods, processes, systems and apparatus for an internal combustion engine.

[0043] Another object of the invention is to devise environmentally friendly, effective, efficient and economically feasible combustion methods, processes, systems and apparatus for electrical energy generation.

[0044] Another object of the invention is to devise environmentally friendly, effective, efficient and economically feasible combustion methods, processes, systems and apparatus for jet propulsion.

[0045] Another object of the invention is to devise effective, efficient and economically feasible combustion methods, processes, systems and apparatus that do not produce oxides of carbon.

[0046] Another object of the invention is to devise effective, efficient and economically feasible combustion methods, processes, systems and apparatus that minimize the production of oxides of nitrogen.

[0047] Another object of the invention is to devise effective, efficient and economically feasible fuel system for an environmentally friendly, effective and efficient combustion methods, processes, systems and apparatus.

[0048] Another object of the invention is to devise effective, efficient and economically feasible fuel methods, processes, systems and apparatus for environmentally friendly, effective and efficient internal combustion engines.

[0049] Another object of the invention is to devise effective, efficient and economically feasible fuel methods, processes, systems and apparatus for environmentally friendly, effective and efficient electricity production.

[0050] Another object of the invention is to devise effective, efficient and economically feasible fuel methods, processes, systems and apparatus for environmentally friendly, effective and efficient heat generation.

[0051] Another object of the invention is to devise effective, efficient and economically feasible combustion methods, processes, systems and apparatus that includes hydrogen and oxygen or hydrogen and air or hydrogen and oxygen and air, wherein the temperature of combustion is controlled so that economical materials of construction for a combustion engine can be used.

[0052] Another object of the invention is to devise effective, efficient and economically feasible methods, processes, systems and apparatus of increasing the efficiency of combustion.

[0053] Another object of the invention is to devise effective, efficient and economically feasible electrolytic methods, processes, systems and apparatus to convert water into oxygen and/or hydrogen utilizing the energy available from combustion.

[0054] Another object of the invention is to devise effective, efficient and economically feasible catalytic methods, processes, systems and apparatus for the conversion of stream into hydrogen, wherein the steam is produced by a combustion engine that is fueled by at least one of: oxygen, hydrogen and water; oxygen, hydrogen, water and nitrogen; oxygen, hydrogen, water and air; hydrogen, water and air.

[0055] Additional objects and advantages of the invention will be set forth in part in a description which follows and in part will be obvious from the description, or may be learned by practice of the invention.

[0056] An improved environmentally friendly process to create energy over that of the combustion of fossil fuels would be a process that does not produce a product of which the earth would have to naturally remove or convert. $H_2O$ is a product which could perform such a task. The Earth is covered mostly by water. Water is made by the combustion of $O_2$ and $H_2$. Further, known methods to produce $O_2$ are by: liquefaction (cryogenic distillation) of air; membrane separation of air, Pressure Swing Adsorption (PSA) of air and electrolysis of $H_2O$. All of these processes are friendly to the environment. In addition, $H_2$ is the most abundant element in the universe existing in nearly all compounds and compositions. Modifying our alcohol, oil, coal and gas refineries to produce $H_2$ would stimulate economic expansion, while focusing the responsibility of air pollution into a refining environment, wherein that responsibility can be managed.

[0057] The discovered WCT manage energy much more efficiently than that of the traditional combustion engine, as the traditional combustion engine relates to transportation, electricity generation and heat generation applications. This is especially the case with respect to the internal combustion

engine. The internal combustion engine, as well as combustion engines generally, loose approximately 60 to 85 percent of their combustion energy in: heat losses from the engine, engine exhaust gases and unused mechanical energy. It is discovered in that this invention recaptures significant energy losses by converting lost energy into potential and into internal energy. This discovery directly follows the first and the second laws of thermodynamics. In one application, an internal combustion engine, exhaust energy is converted into chemical potential energy.

[0058] The discovered WCT utilize the energy of combustion of $O_2$ with $H_2$ as the energy source for combustion methods, processes, systems and apparatus to create energy. The combustion product of $O_2$ and $H_2$ is $H_2O$. This combustion reaction is somewhat similar to that of hydrocarbon combustion; however, carbon is removed from the reaction and $N_2$ is partially or totally removed from the reaction. In summary, WCT eliminates environmental issues associated with the combustion of C, N and/or S.

$$2H_2 + O_2 \longrightarrow 2H_2O + 137\text{ kcal}$$

[0059] At 68.5 kcal/mole, $H_2$ has an energy value of 34 kcal per pound; this compares favorably to n-Octane which is 1300 kcal/mole=11 kcal per pound and methane which is 213 kcal/mole=13 kcal per pound.

[0060] While $H_2O$ is an environmentally friendly combustion product, the combustion temperature of $O_2$ with $H_2$ is too high for most combustion materials. And, especially in the case of the internal combustion engine, the implementation of any new combustion system would be significantly facilitated through the use of traditional materials of construction, so as to minimize the cost of engine construction. $H_2O$ is preferably used to control the combustion temperature of $O_2$ with $H_2$. Said $H_2O$ can be in one of three forms: a solid (ice particles), a liquid (water vapor) and a gas (steam). If $H_2O$ is in the form of a solid, the combustion temperature will be controlled by: the heat capacity of solid $H_2O$, the sublimation energy of $H_2O$, the heat capacity of liquid $H_2O$, the latent heat of vaporization of $H_2O$ and the heat capacity of steam. If $H_2O$ is in the form of a liquid, the combustion temperature will be controlled by: the heat capacity of liquid $H_2O$, the latent heat of vaporization of $H_2O$ and the heat capacity of steam. If the $H_2O$ is a gas, the temperature will be controlled by the heat capacity of steam.

[0061] Air has traditionally been used as the combustion oxidant ($O_2$ in air). The combustion of $O_2$ with $H_2$, without the inclusion of $N_2$ and/or Ar or with a minimal inclusion of $N_2$ and/or Ar from air, improves internal combustion energy output by over 300 percent. This aspect of the instant invention can be readily seen by comparing a combustion system which utilizes air for the oxidant, wherein air is approximately only 20 percent $O_2$ and 78 percent $N_2$, and a combustion system which utilizes very pure $O_2$ as the oxidant. Nitrogen reduces the combustion temperature while endothermically producing $NO_X$, thereby creating pollution while reducing engine efficiency. Since air is approximately 78 percent $N_2$, nearly 78 percent of the combustion mixture in a traditional combustion engine provides no energy during combustion, and in actuality, reduces the energy output of combustion. While the $N_2$ in air can keep the combustion temperature down, thereby producing exhaust gas temperatures approximately near or below 1000° F., so that the combustion temperature is not harmful to traditional materials of engine construction, the addition of $H_2O$ to an $O_2/H_2$ fuel mixture approaches isothermal combustion producing steam while cooling the temperature of combustion, thereby converting combustion heat energy into an energy form that is easily utilized and/or recycled. The inclusion of $N_2$ does not provide the ability of energy recycle. The same discussion applies to Ar.

[0062] As is readily understood in combustion science, there are three components required for combustion to commence: fuel, heat and ignition. Assuming a constant source of fuel ($H_2$ and $O_2$) and ignition, the addition of $H_2O$ to the combustion mixture presents a method and process to: limit the combustion temperature, minimize $NO_X$ formation, and minimize the cost of materials of construction for the combustion engine, as well as maintain a high enough combustion temperature so that combustion may commence. The addition of $H_2O$ to the combustion chamber can be managed to maintain combustion, as well as control the temperature of combustion. Varying engine configurations, combustion chamber designs and materials of construction will determine the limits of $H_2O$ addition to the combustion chamber within the limits of fuel mixture and combustion temperature. Varying engine configurations, combustion chamber designs and materials of construction will determine the limits of $H_2O$ addition to the combustion chamber within the limits of fuel mixture and combustion temperature. The addition of excess air to the combustion chamber can be managed to maintain combustion, as well as control the temperature of combustion. This concept is especially practical in jet propulsion applications.

[0063] $H_2O$ is discovered in this invention as a coolant and as a fuel, as well as a combustion product. $H_2O$ is presented in novel energy recycle methods, processes, systems and apparatus to improve the efficiency of combustion by utilizing water as a combustion product, an energy conduit, a combustion coolant and an energy storage medium. The discovered WCT presents $H_2O$ as at least one of: an energy storage medium, a combustion product, a coolant and an energy transfer conduit and/or any combination therein. The importance of this aspect of the invention can be appreciated by thermodynamic principals. By the first law of thermodynamics, heat added to the system plus work done on the system equals changes in internal energy plus changes in potential and kinetic energy. The recycling of otherwise lost energy increases both internal and potential energy, thereby increasing efficiency of the combustion systems. By the second law of thermodynamics: changes in internal energy equal changes in entropy (at a specific temperature) minus work performed by the system. Since the WCT significantly reduces changes in entropy by focusing otherwise lost entropy and enthalpy into an exhaust enthalpy/entropy which can be recycled into internal and potential energy, the WCT significantly increases internal and potential energy, thereby significantly increasing efficiency. The WCT uses the first and second laws of thermodynamics as an asset. In contrast, hydrocarbon combustion technologies have the first and second laws of thermodynamics as a liability. Further, the use of $H_2O$ in the combustion chamber theoretically approaches isothermal combustion.

[0064] It has been learned in the industry that frozen crystals of methane in a $H_2$ gas allow the $H_2$ to form a gel of $H_2$ and methane. Such gel compositions are easier to handle than their cryogenically stored $H_2$. It is an embodiment of the WCT to store at least one of $H_2$ and $O_2$ as a gel wherein the gel contains frozen water crystals, thereby improving the storage characteristics of said $H_2$ or $O_2$.

[0065] The WCT utilizes electrochemical pathways to convert $H_2O$ into $O_2$ and $H_2$, wherein the electrical energy for these pathways is obtained from at least one of: cooling the engine, exhaust gas energy, combustion output mechanical energy, photovoltaic energy and the energy of air or water motion. Given that the efficiency of most combustion engines (especially the internal combustion engine) is only approximately 20 percent, the discovered WCT can significantly increase the combustion efficiency. Assuming that the available $H_2$ fuel has a conversion efficiency near that of its hydrocarbon predecessors, thereby presenting a source value of 100 percent for fresh $H_2$ and that the separation of air into $O_2$, $N_2$ and Ar has an efficiency of conservatively near 20 percent, WCT methods, processes, systems and apparatus have the capability to increase the efficiency of a turbine combustion engine to near 40 to 70 percent and the efficiency of the internal combustion engine to near approximately 60 to 70 percent. It is theorized that the combustion efficiency can be increased further, depending on the separation efficiency of air into $O_2$, $N_2$ and Ar, the conversion efficiency of steam into electricity and in most applications the conversion efficiency of electricity into $H_2$ and $O_2$. It is discovered that the theoretical limit of efficiency for the discovered WCT is approximately limited to the efficiency limit in the conversion of steam, mechanical, photovoltaic, wind and waterwheel energy to electricity in combination with the efficiency limit of electrolysis to convert $H_2O$ into $H_2$ and $O_2$ minus friction losses. This theoretical limit presents that the theoretical efficiency limit of the methods, processes, systems and apparatus of the WCT is near approximately 70-90 percent. (There is an interesting situation, wherein the engine is not running and a photovoltaic cell increases the potential energy by creating fuel from water. Under this scenario the engine actually increases its fuel without using any fuel, wherein the efficiency is infinate.)

[0066] The discovered WCT present methods, processes, systems and apparatus for separating $O_2$ and $N_2$ from air in combination with the combustion of $O_2$ with $H_2$. There are three methods of separation. By the first method, air is separated utilizing the cryogenic distillation process, which is used to pressure, chill and distill the air, separating air into $O_2$ and $N_2$. By the second method, air is separated utilizing membranes; the membranes can be of either organic polymer construction or of inorganic construction. By the third method, air is separated by utilizing Pressure Swing Adsorption (PSA). Utilizing PSA it is preferred that $O_2$ be absorbed; however, it is practical that $N_2$ be absorbed. The separated $O_2$, produced by at least one of these methods, is preferably used as a fuel in the combustion systems.

[0067] Cryogenic Distillation—In the chemical industry, cryogenic distillation of air into $O_2$ and $N_2$ is a common pathway to produce these elemental diatomic gases. However, it has not been proposed previously and it is novel to utilize this process: in combination with $H_2$ distillation, to fuel the combustion of $O_2$ with $H_2$ and/or to utilize the energy of the combustion of $O_2$ with $H_2$ to power the cryogenic distillation of air. In addition, nearly all industrial processes for the separation of air into $O_2$ and $N_2$ utilize $N_2$ or $N_2$ and Ar as industrial products. In the case of the discovered WCT, the primary use of distilled $N_2$ and/or Ar would be as a heat sink. This heat sink is preferably utilized to perform at least one of: cool the storage of $O_2$ or of $H_2$, facilitate cryogenic distillation, cool the combustion engine and/or provide refrigeration and/or provide environmental cooling. In the case of the internal combustion engine, this heat sink is preferably used in place of the engine water coolant cooling system (typically a fan cooled radiator) and/or the compressor for the passenger cooling (air conditioning) system. The distillation of Ar is immaterial except as a combustion efficiency improvement; the additional fractionating column to separate Ar should be viewed on a capital investment—efficiency rate of return analysis.

[0068] Membrane Separation—Membrane separation is much simpler than cryogenic distillation; however, nitrogen is not available as a heat sink. By utilizing the membrane separation process, separate cooling systems will need to potentially be available for the engine and for any passenger or environmental cooling.

[0069] PSA—PSA separation is simpler than cryogenic processes yet more complicated than membrane separation. PSA has the same drawback as membrane separation; $N_2$ would not be available as a heat sink. By utilizing a PSA separation process, separate cooling systems will need to potentially be available for the engine and for any passenger or environmental cooling.

[0070] The discovered WCT relate to chemical methods, processes, systems and apparatus of producing $H_2$ from steam, since steam is the physical state of the water product from combustion. The WCT converts steam into $H_2$ utilizing a process, which is normally considered a detriment. The WCT utilizes corrosion to chemically convert steam to $H_2$. Corrosion utilizes $O_2$ to convert a metal to its metal oxide, while releasing $H_2$. This metal oxide has traditionally been viewed as a detriment since the metal oxide has less strength, durability and luster than its metal counterpart. The general chemical reaction for corrosion with water as the oxidant would be:

$$M + H_2O \xrightarrow{eV} MO + H_2$$

[0071] where, M is any metal or combination of metals from the Periodic Table and eV is the electromotive potential. Due to the electromotive potential of corrosion, many methods of protecting a metal against corrosion are based upon managing the electromotive potential of the metal. One such method is cathodic protection. Under cathodic protection, the metal is protected against corrosion by producing an electromotive potential in the metal that is counter to the electromotive potential for corrosion of that metal. Where traditional cathodic protection methods are used to prevent corrosion, the WCT proposes driving corrosion by creating an anodic potential. The WCT utilizes catalytic sacrificial metal(s) in the exhaust gas (steam), wherein an anodic potential is preferably used to drive corrosion of a metal or a composition of metals, thereby converting at least a

portion of the steam to hydrogen. (A good reference for electromotive potentials would be the Handbook of Chemistry and Physics by CRC Press.)

[0072] The discovered WCT relate to electrolytic methods, processes, systems and apparatus to electro-chemically convert $H_2O$ into $O_2$ and $H_2$. It is to be understood that under the best of engineered circumstances, the electrical energy required by electrolysis to convert $H_2O$ into $O_2$ and $H_2$ will be greater than the energy obtained by the combustion of $O_2$ and $H_2$. However, electrolysis allows for significant improvements in the efficiency of combustion by reclaiming energy which would otherwise be lost.

[0073] Whether electrical energy is generated from the steam of combustion or from at least one of: mechanical energy conversion, steam energy conversion, light energy conversion, wind energy conversion or water wheel energy conversion, once the capital cost of conversion equipment is in place, the cost of energy conversion is limited to equipment maintenance expense. Four types of available electrical energy generation are discovered: mechanical energy, steam energy, moving air (wind) or water energy and photovoltaic (sun) energy.

[0074] Electrolysis may create enough fuel from $H_2O$ at a very low energy conversion cost to increase the efficiency of the entire combustion system. The application of the internal combustion engine is an excellent example of a situation wherein electrolysis may be used to turn $H_2O$ into a fuel source (potential energy). The internal combustion engine, once in operation, turns normally at approximately 500 to approximately 6000 rpm and infrequently in specially engineered situation to approximately 10,000 to 20,000 rpm. There are many situations in the operation of combustion engines wherein a generator either located on the drive shaft or activated by a transmission device and driven by the drive shaft, could be turned by the mechanical energy of the combustion engine to create an electrical current for the electrolytic conversion of $H_2O$ into $O_2$ and $H_2$. In addition, to the extent that $H_2O$ is utilized to control the combustion temperature of the combustion system is to the extent that a steam driven turbine generator can be further utilized in the exhaust stream of the WCT to create electricity. Electricity can then be used for the electrolysis of $H_2O$ into $O_2$ and $H_2$. Once the capital cost of either the mechanical driven generator or the steam driven generator has been made, the conversion cost of the mechanical or steam energy to electricity is limited to equipment maintenance expense. This same cost/benefit scenario would apply to a moving air (wind) or water driven generator, as well as to the photovoltaic system.

[0075] The WCT relates to the application of muffler technologies as those technologies are known and used to muffle the noise of combustion. In the case of the internal combustion engine, mufflers are installed to limit the noise produced by combustion. While muffler designs do control the noise or air vibration from a combustion engine, current muffler designs waste available combustion exhaust gas energy. The installation of a steam turbine in the combustion engine exhaust gas stream is preferred to produce an electrical current. It is preferred that the steam turbine absorb air vibration from combustion. It is preferred to install easily oxidized metal(s) in a contact/muffler chamber to create $H_2$ from the steam produced in the combustion systems. The combination of a steam driven turbine generator and catalytic conversion metal(s) in the exhaust would be a most preferred combination to convert the steam energy of the exhaust gases from the combustion systems into electrical energy, while muffling the air vibration in the exhaust gases.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0076] A better understanding of the present invention can be obtained when the following description of the preferred embodiments are considered in conjunction with the following drawings, in which:

[0077] **FIGS. 1 and 1A** provide a key to the symbols of Flow Diagram 1 and **FIGS. 2 through 24**.

[0078] **FIG. 2** illustrates in block diagram form a general thermodynamic description of a traditional hydrocarbon combustion engine.

[0079] **FIG. 2A** illustrates in block diagram form a general description of proposed methods, processes, systems and apparatus to manage $H_2O$, $O_2$, $H_2$ and air in the discovered WCT combustion engine.

[0080] **FIG. 3** illustrates in block diagram form a general description of proposed methods, processes, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates alternate methods, processes, systems and apparatus to create electricity for electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0081] **FIG. 4** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$.

[0082] **FIG. 5** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates the cryogenic distillation of air into nitrogen and $O_2$.

[0083] **FIG. 6** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, as well as electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0084] **FIG. 7** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the combustion temperature and the fuel system incorporates the cryogenic distillation of air into nitrogen and $O_2$, as well as electricity for electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0085] **FIG. 8** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the cryogenic distillation of air into nitrogen and $O_2$, as well as electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0086] **FIG. 9** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA.

[0087] **FIG. 10** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA, as well as electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0088] **FIG. 11** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA, as well as alternate methods, processes, systems and apparatus to create electricity for electrolysis to convert $H_2O$ into $H_2$ and $O_2$.

[0089] **FIG. 12** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the cryogenic distillation of air into nitrogen and $O_2$.

[0090] **FIG. 13** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA.

[0091] **FIG. 14** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for heating the combustion mixture for a combustion engine that is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0092] **FIG. 15** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates the cryogenic distillation of air into nitrogen and $O_2$.

[0093] **FIG. 16** illustrates in block diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA.

[0094] **FIG. 17** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the cryogenic distillation of air into nitrogen and $O_2$.

[0095] **FIG. 18** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature, and wherein the fuel system incorporates catalytic conversion of steam into $H_2$, along with the separation of air into nitrogen and $O_2$ with at least one of membranes and PSA.

[0096] **FIG. 19** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for heating the combustion mixture for a combustion engine that is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0097] **FIG. 20** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for liquefaction and cooling of $O_2$ and/or $H_2$ storage for a combustion engine that is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0098] **FIGS. 21 and 21A** illustrate in bock diagram form a general description of proposed methods, procedures, systems and apparatus for steam turbine(s), wherein the steam turbine(s) located in and powered by the exhaust of a combustion engine fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0099] **FIG. 22** illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for an air turbine, wherein said air turbine provides electricity to separate $H_2O$ into $H_2$ and $O_2$ for a combustion engine, wherein said combustion engine is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and

air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0100] FIGS. 23 and 23A illustrate in bock diagram form a general description of proposed methods, procedures, systems and apparatus for a $H_2O$ turbine, wherein said $H_2O$ turbine provides electricity to separate $H_2O$ into $H_2$ and $O_2$ for a combustion engine, wherein said combustion engine is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

[0101] FIG. 24 illustrates in bock diagram form a general description of proposed methods, procedures, systems and apparatus for pressure control for a combustion engine, wherein said combustion engine is fueled by at least one of: $O_2$ and $H_2$; air and $H_2$; $O_2$, $H_2$ and air wherein $H_2O$ is an option to cool the combustion chamber and to cool the combustion temperature.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0102] The timing of the invention is significant since global warming is becoming a global political issue. The timing of the invention is significant since the availability of oil and natural gas, the sources of hydrocarbons, are becoming global political issues. The timing of the invention is significant since air pollution is becoming a health issue for much of humanity. The timing of the invention is significant since the market of natural gas (methane, ethane, propane and/or butane) is affecting the production and/or market price of electricity. The WCT presents environmentally friendly combustion methods, processes, systems and apparatus, which are efficient and which will require a reasonable amount of tooling to implement. And, in the case of the internal combustion engine, the WCT present a combustion process, which will have a "feel" to the driver which is similar to that of hydrocarbon combustion engines; this "feel" will further implementation of the invention.

[0103] The methods, processes, systems and apparatus of the WCT solve the myriad of challenges that have kept hydrogen based combustion technologies from commercialization. These challenges are, yet are not limited to: 1) fuel combustion temperature and the associated combustion engine cost, 2) the volume of fuel required and the associated fuel storage requirements, 3) engine efficiency and the associated fuel required, 4) the generation of $NO_X$, 5) engine efficiency and the associated cost of operation, 6) combustion engine size and the associated combustion engine cost, 7) required fuel and fuel storage in general, 8) cost of operation in general, 9) combustion engine cost in general, and in the case of the internal combustion engine 10) an engine that meets customer expectations for feel, efficiency, cost and environmental impact.

[0104] The methods, processes, systems and apparatus of the WCT utilize the heat of combustion of $O_2$ with $H_2$ as the primary energy source for combustion systems to create energy. A preferred embodiment of the WCT would be a fuel mixture of $O_2$ and $H_2$. A most preferred embodiment of the WCT would be to add $H_2O$ to the combustion chamber to control the combustion temperature. It is an embodiment to cool the engine with $H_2O$ in the combustion chamber, wherein the gas of combustion is at least one of water vapor and steam. It is an embodiment to cool combustion with an excess of air. It is a preferred embodiment of WCT to manage the final temperature in the combustion mixture prior to ignition so that the mixture is in at least one of a gaseous or fluid state. It is a preferred embodiment that the combustion methods, processes, systems and apparatus of the WCT be at least one of: internal combustion, open flame (heating) combustion and turbine combustion, as these applications are known in the art of combustion science.

[0105] Since the storage of $O_2$ and $H_2$ would be best accomplished at cryogenic temperatures, cryogenic $O_2$ and/or cryogenic $H_2$ can be used to at least partially control combustion temperature. A preferred embodiment of the WCT would be to at least partially control the combustion temperature and/or the engine temperature by the temperature of $O_2$ and/or $H_2$. It is most preferred to preheat at least one of: $O_2$, $H_2$, and $H_2O$ to a temperature/pressure combination that allows for efficient combustion. To manage this energy it is a preferred embodiment to heat at least one of the: $O_2$, $H_2$, combustion $H_2O$ and any combination therein by heat exchange from at least one of: ambient temperature, engine combustion energy, engine exhaust steam energy and radiant energy from an electrical resistant heating device and any combination therein. It is most preferred to preheat at least one of $O_2$ and $H_2$ from the ambient temperature prior to heating either: $O_2$, $H_2$ or $H_2O$ by heat exchange from at least one of: ambient temperature, engine combustion energy, engine exhaust steam energy, an electrical radiant heat energy source and any combination therein. Since the heat capacity of water is much greater than that of water vapor (steam) and the latent heat of vaporization of water is a significant heat sink, it is a most preferred to heat the $H_2O$ to a liquid state and not to a gaseous or fluid state (steam). FIG. 19, approximates the preferred embodiment of heating the combustion mixture. While not most preferred, an embodiment of combustion would be to add $H_2O$ with at least one of $N_2$ and Ar to the combustion chamber, utilizing as a heat sink the $H_2O$ as well as $N_2$ and/or Ar to control the combustion temperature. While not preferred, an embodiment would be to utilize air instead of $O_2$ as a source of $O_2$, whenever enough $O_2$ is not available, to combust with $H_2$ to produce $H_2O$ as the primary combustion product, knowing that $NO_X$ will be a secondary combustion product. It is preferred to use an excess of air in the event that air is used instead of $O_2$ as a source of $O_2$; excess air is preferred to control combustion temperature and thereby minimize $NO_X$ formation in the event that pure $O_2$ is not available. An embodiment for the combustion of air and $H_2$ is preferably accomplished with $H_2O$ added to the combustion chamber, thereby utilizing $H_2O$ as a heat sink to reduce the combustion temperature, thereby minimizing $NO_X$ production; the use of $H_2O$ as a heat sink has the additional benefit of producing additional steam in the exhaust. For brevity, the methods, processes, systems and apparatus of the most preferred embodiment(s), the preferred embodiment(s) and the embodiment(s) of combustion will be herein after be referred to as WCT. Methods, processes, systems and apparatus for the WCT are approximated in FIGS. 2 through 24.

[0106] Cryogenic Distillation—Methods, processes, systems and apparatus for WCT that incorporate Cryogenic distillation are approximated in FIGS. 5, 7, 8, 12, 15 and 17. Cryogenic distillation principals incorporated into the WCT are those principles as are known in the art of cryogenic distillation. It is to be understood that per the Vapor-Liquid-Equilibrium diagram for each stage of distillation, the tem-

perature of distillation is dependent upon the distillation pressure; higher separation pressures lead to higher separation temperatures. It is to be understood that the $N_2/O_2$ separation portion contains either one, two or three columns for the production of $O_2$, depending on the purity desired; the second column may be eliminated to reach purities of $O_2$ which are less than that of pure $O_2$. The third column is desired to separate Ar from $O_2$, thereby producing very pure $O_2$.

[0107] A most preferred embodiment is to cool the air for distillation utilizing at least one of the Joule Thompson Effect and counter-current heat exchange. A preferred embodiment is to cool the air for distillation utilizing at least one of the Joule Thompson Effect and the vaporization of a liquid. An embodiment is to cool the air for distillation utilizing at least one of the Joule Thompson Effect and the expansion of a gas doing work in an engine. A most preferred embodiment is to operate the first stage distillation column at 100 to 200 psia. A preferred embodiment is to operate the first stage distillation column at atmospheric to 500 psia. A preferred embodiment is the use of recycled $N_2$ as a heat sink, wherein said $N_2$ is used to cool at least one of: $O_2$ storage, $H_2$ storage, a cooling system of the combustion engine, a cooling system for electrolysis, the combustion engine, electrolysis, air in an air conditioning system, any portion of cryogenic distillation of air and/or any combination therein. A most preferred embodiment is to cryogenically distill air, wherein the energy utilized for cryogenic separation is energy generated by the WCT and wherein the separated $O_2$ from cryogenic distillation is utilized as a fuel in the WCT.

[0108] **FIGS. 5, 7, 8, 12, 15 and 17** approximate methods, processes, systems and apparatus of the WCT, wherein cryogenic distillation is used to separate air, wherein $O_2$ from said separation is used as a fuel in said WCT.

[0109] Membranes—Membranes, of either organic or inorganic construction, can effectively be used to separate air into $O_2$. Membrane separation principals incorporated into the WCT are to be those principles as known in the art of membrane separation. Staged membrane separation is preferred to produce very pure $O_2$. With the use of inorganic or organic polymer membranes, it is preferred to place an electrical potential across a membrane designed to hold an electrical potential to facilitate separation. It is most preferred to utilize at least one of organic and inorganic membranes to separate air, wherein the $O_2$ from said separation is used as a fuel in WCT. It is most preferred to utilize the energy of combustion from WCT to provide energy, wherein said energy powers the flow of air through said membrane(s), wherein said membrane separates air, wherein the $O_2$ from said separation is used as a fuel in WCT.

[0110] PSA—Whether of positive pressure or vacuum adsorption, PSA can effectively be used to separate air. PSA principals incorporated into the WCT are those principles as are known in the art of PSA. While there are material designs for the adsorption of $O_2$ as well as $N_2$, it is preferred to perform $O_2$ adsorption to minimize the size of PSA. It is most preferred to utilize PSA to separate air, wherein the $O_2$ from said separation is used as a fuel in WCT. It is most preferred to utilize the energy of combustion from the WCT to provide energy, wherein said energy powers said PSA, wherein said PSA separates air, wherein the $O_2$ from said separation is used as a fuel in the WCT.

[0111] **FIGS. 9, 10, 11, 13, 16 and 18** approximate methods, processes, systems and apparatus of the WCT, wherein at least one of organic membrane(s), inorganic membrane(s), PSA and/or any combination therein is used to separate air, wherein $O_2$ from said separation is used as a fuel in said WCT. In these figures, liquefaction of either $H_2$ or $O_2$ is a depicted option. It is preferred to utilize warm generated $O_2$ and $H_2$ in combustion as a first preference over liquefied $O_2$ or $H_2$; therefore, it is most preferred that any liquefaction be performed in storage as depicted in **FIG. 20**.

[0112] The WCT relates to chemical methods of producing $H_2$ from steam, since steam is the physical state of the water product from the WCT. **FIGS. 4, 6, 8, 11, 12, 13, 14, 17 and 18** approximate methods, processes, systems and apparatus discovered in this aspect of the WCT. The WCT converts steam into $H_2$ utilizing the corrosion process. A preferred embodiment is to chemically convert the steam produced by WCT into $H_2$ utilizing the corrosion of at least one metal. A most preferred embodiment is to chemically convert the steam produced by WCT into $H_2$, wherein said $H_2$ is produced by the corrosion of at least one metal, wherein that corrosion is enhanced by an electrical current in the metal(s). A preferred embodiment to chemically convert the steam produced by WCT into $H_2$, wherein said $H_2$ is created by the corrosion of at least one metal, wherein said $H_2$ is used as a fuel in said WCT. A most preferred embodiment is to chemically convert the steam produced by WCT into $H_2$, wherein said $H_2$ is created by the corrosion of at least one metal, wherein said corrosion is enhanced by an electrical current in the metal(s), wherein said $H_2$ is used as a fuel in the WCT. In many of these figures liquefaction of $H_2$ is a depicted option. It is preferred to utilized warm generated $H_2$ in combustion as a first preference over liquefied $H_2$; therefore, it is most preferred that any liquefaction be performed in storage as depicted in **FIG. 20**.

[0113] The WCT relate to electrolysis methods, processes, systems and apparatus to electrolytically convert $H_2O$ into $O_2$ and $H_2$, wherein said $O_2$ and $H_2$ are used as fuel in the WCT. Electrolysis principals incorporated into the WCT are to be those principles as known in the art of electrolysis. **FIGS. 3, 6, 7, 8, 10 and 11** approximate the methods, processes, systems and apparatus for electrolysis in the WCT. It is preferred to utilize warm generated $O_2$ and $H_2$ in combustion as a first preference over liquefied $O_2$ or $H_2$; therefore, it is most preferred that any liquefaction be performed in storage as depicted in **FIG. 20**. As a most preferred embodiment, the WCT stores energy by the potential chemical energy available in $H_2O$ prior to electrolytic separation, as well as in $O_2$ and in $H_2$. Said $O_2$ and $H_2$ are available for fuel in the WCT and/or for a fuel cell to create electrical energy. As a most preferred embodiment, the WCT stores energy by the potential chemical energy available in $H_2O$, wherein said $H_2O$ can electrolytically be converted to $O_2$ and $H_2$, wherein at least a portion of said electrolytically converted $O_2$ and/or $H_2$ is used as fuel in the WCT and/or in a fuel cell to create electrical energy. As a preferred embodiment, the WCT stores energy by the potential chemical energy available in at least one of: $H_2O$, $O_2$, $H_2$ and any combination therein.

[0114] Since many combustion systems, methods, engines and apparatus have a mechanical power output or mechanical energy rotating shaft, nearly all applications of the WCT have the capability to convert available mechanical rotating

energy into electrical energy. Conversion of available mechanical rotating energy into electrical energy is preferred utilizing an electrical generation device; most preferably a generator. It is an embodiment that an alternator or dynamo is used, wherein said electrical energy from an alternating current may be converted to a direct current. It is an embodiment for the WCT to perform work other than create electrical energy, generate heat or generate steam, wherein said generator is utilized inversely proportional to the mechanical work or torque performed by the WCT. It is a preferred embodiment that the mechanical rotating energy produced by the WCT enter a transmission, wherein said transmission engage in a manner that is inversely proportional to the torque and/or work output of the WCT, wherein said transmission output mechanical rotating energy turn said generator to create said electrical energy. Said transmission is to be as is known in the art. It is most preferred that said transmission engage a flywheel capable of storing rotational kinetic energy, wherein said flywheel turns said generator. **FIGS. 3, 6, 7, 8, 10** and **11** approximate methods, processes, systems and apparatus to recycle mechanical rotating energy as discovered. A preferred embodiment is the conversion of mechanical rotating energy created by the WCT into electrical energy utilizing an electrical generator device. A most preferred embodiment is wherein said electrical energy from said electrical generator device is utilized in the electrolysis of $H_2O$ into $H_2$ and $O_2$. A most preferred embodiment is the conversion of mechanical rotating energy created by the WCT into electrical energy utilizing an electrical generator device, wherein said electrical energy is utilized in the electrolysis of $H_2O$ into $H_2$ and $O_2$, wherein said $H_2$ and/or $O_2$ is used as fuel in the WCT.

[0115] Fuel Storage—By the ideal gas law (PV=nRT), it can be surmised that the efficiency of compression and efficiency of storage for $O_2$ and/or $H_2$ increases significantly if the $O_2$ and/or the $H_2$ is stored at cryogenic temperatures. It is preferred to store at least one of $H_2$ and/or $O_2$ at cryogenic temperatures. It is preferred to store at least one of $H_2$ and/or $O_2$ in a liquid state. Due to the explosive and flammable nature of $H_2$ and $O_2$, it is preferred to utilize $N_2$ as a refrigerant for the storage of at least one of $H_2$ and $O_2$. Due to the negative Joule Thompson curve for $H_2$, it is most preferred to cool $H_2$ prior to any attempted cryogenic chilling or liquefaction. Due to the rather extreme explosive nature of $O_2$, it is preferred to limit the required storage of $O_2$ with preference to any of said $O_2$ generating technologies (cryogenic distillation, membrane separation and/or PSA). To maintain fuel storage temperatures, it is preferred to operate a compressor for at least one of: liquefaction of $O_2$, chilling of $O_2$, liquefaction of $H_2$, chilling of $H_2$ and any combination therein. It is most preferred that said compressor be powered by the WCT. **FIG. 20**, illustrates in block diagram form chilling and/or liquefaction of $O_2$ and/or $H_2$.

[0116] Since nearly all applications of WCT have an engine exhaust, nearly all applications of the WCT will have the ability to convert combustion exhaust energy into electrical energy. It is preferred to insulate the WCT, as is known in the art of insulation, to manage energy. Insulation is most preferred in the WCT and the WCT exhaust, to thereby minimize WCT enthalpy losses. Conversion of exhaust energy is preferably performed utilizing a steam turbine. **FIGS. 3, 6, 7, 8, 10, 11, 14, 15, 16, 17, 18, 21** and **21A** approximate the methods, processes, systems and apparatus to convert steam energy into electrical energy. Steam turbine principals incorporated into the WCT are those principles as are known in the art of steam turbine technology. A preferred embodiment is the conversion of steam energy, wherein said steam energy is created by the WCT, wherein said steam energy is converted into electrical energy utilizing at least one steam turbine, wherein said steam turbine(s) turns at least one generator creating said electrical energy. It is preferred that said electrical energy be regulated. In the case wherein an alternator is used, it is preferred that said electrical energy be converted from an alternating current to a direct current, as is known in the art. A most preferred embodiment is wherein at least a portion said electrical energy is utilized in the electrolysis of $H_2O$ into $H_2$ and $O_2$. A most preferred embodiment is the conversion of steam energy created by the WCT into electrical energy utilizing at least one steam turbine, wherein each said steam turbine(s) turn a generator device, wherein said generator device(s) creates an electrical current, wherein at least a portion of said electrical current is utilized in the electrolysis of $H_2O$ into $H_2$ and $O_2$, wherein at least a portion of said $H_2$ and/or $O_2$ is used as fuel in said WCT.

[0117] It is preferred that many applications of the WCT perform some type of movement; therefore many applications of the WCT will have an available source of moving air or moving water. Applications of the WCT will have the ability to convert the energy of moving air or water. **FIGS. 3, 6, 7, 8, 10, 11** and **22** approximate the methods, processes, systems and apparatus to convert moving air energy into electrical energy. A preferred embodiment of the WCT is the conversion of the energy of moving air or water into electrical energy, wherein said electrical energy is created by a generator from the moving air or water utilizing a generator which turns in direct consequence of the moving air or water, wherein at least a portion of said electrical energy is utilized in the electrolysis of $H_2O$ into $H_2$ and $O_2$. It is preferred that said electrical energy be regulated. In the case wherein an alternating current is created, it is preferred that said electrical energy be converted to a direct current. A most preferred embodiment is use of at least a portion of said $H_2$ and/or $O_2$ as fuel in the WCT.

[0118] Steam Turbine Method, Process and System

[0119] The energy of steam is measured in temperature and in pressure. Assuming saturated steam, steam energy is measured by pressure alone, i.e. the steam is normally termed 150, 300 or 400 psig steam, etc. Only in the case superheated steam is steam energy measured by both pressure and temperature. Steam looses temperature and pressure as steam energy is used and/or lost. Upon loosing energy, steam temperature and pressure (usually just measured as pressure) reduces and the steam begins condensing water. Once all of the steam energy is depleted, there is no pressure or water vapor, just hot water. Using this knowledge, one may expect all electrical generation facilities to use every last BTU or psig of steam. Such is not done, because such is not economical, given the required investment in pollution control equipment, heat transfer equipment (boilers) and in steam turbines. It is common for steam generation facilities to operate the final stage of electrical generation wherein the final steam turbine operates at less than atmospheric pressure, 14.7 PSIA=0 PSIG. However, in the case of WCT, pollution control equipment is minimized in combustion and heat transfer equipment is eliminated, thereby reducing investment and improving heat transfer.

Heat transfer equipment is minimized or eliminated because the exhaust of the WCT Engine, steam, is directly transferred to the steam turbine. In the case of hydrocarbon combustion, energy of the hot gasses of combustion are transferred via a heat exchanger to water, thereby creating steam, after which said hot gases are transferred to environmental protection equipment. Said heat exchanger(s) are normally called boilers. The discovered WCT eliminate the need for boilers to generate steam, thereby improving heat transfer, thereby improving steam generation efficiency.

[0120] It is preferred that steam turbine(s) of the WCT be installed in a configuration, wherein the exhaust of the WCT turn said steam turbine(s). Removal of steam energy is most preferably performed in a staged system, wherein at each stage a portion of the energy of the steam is removed by a steam turbine and the resulting condensation is removed prior to the next steam turbine or stage of energy removal. It is most preferred that all of the steam energy (pressure) be removed by the steam turbine/water removal system(s). It is most preferred that the condensation generated during the generation of electricity be transferred to electrolysis. It is preferred that at least a portion of the energy of the steam (pressure) be removed by the steam turbine/water removal system. **FIGS. 21 and 21A** approximates the methods, processes, systems and apparatus to convert steam energy into electrical energy.

[0121] Air and Water Motion Turbine Method and System

[0122] The energy of moving air or water is measured in mass and velocity. Since the mass of air or water into an air or water turbine is equals the mass out of said turbine, the change in velocity is the measure of energy removal. That energy difference can be directly calculated using the laws of physics, specifically kinetic energy. However, it must be noted that the difference in velocity, the removed energy, which can be converted into electrical energy by the turbine will have an opposite drag force. For a stationary combustion engine of the discovered WCT, said drag force can be counterbalanced by the support structure of the turbine. However, in transportation applications wherein the drag force is counter to the direction of motion, said drag force will reduce transportation efficiency. In transportation applications, the vehicle inherently contains a drag force that reduces transportation efficiency. To the extent that said contained drag force can be utilized to convert moving air or water energy into electrical energy at a cost that is less than the energy losses in said contained drag force, is to the extent that said wind and/or water turbine will have practical application. One such application is that of a sail boat, wherein the drag force is in the same direction as the direction of motion. **FIG. 22** approximates WCT methods, processes, systems and apparatus to convert moving air energy into electrical energy.

[0123] In water applications, wave energy (vertical energy) is much greater than the energy of the water's movement (horizontal energy). It is preferred in water applications that a generator be driven by the energy of the vertical wave movement. **FIGS. 23 and 23A** approximates WCT methods, processes, systems and apparatus to convert moving water energy into electrical energy. It is preferred to use said electrical energy from said water energy to electrolytically convert $H_2O$ into $H_2$ and $O_2$. It is most preferred to use said $H_2$ and/or said $O_2$ as fuel for said WCT.

[0124] Photovoltaic Cells

[0125] Wherein light is available, it is an embodiment to utilize photovoltaic cells to create electricity. It is preferred to use said electricity from said photovoltaic cells to electrolytically convert $H_2O$ into $H_2$ and $O_2$. It is most preferred to use said $H_2$ and/or said $O_2$ as fuel for the WCT.

[0126] Fuel Cells

[0127] Wherein electricity is required, it is an embodiment to utilize fuel cells to create electricity. In such applications, $H_2$ and potentially $O_2$ with a fuel cell would replace a battery. It is preferred to create said electricity with a fuel cell when the WCT is not in operation. It is preferred to utilize a fuel cell to power a compressor for chilling and/or liquefaction of $H_2$ and/or $O_2$. It is most preferred to utilize the WCT to create electricity. It is preferred that said fuel cell be powered by hydrogen and at least one of $O_2$ and air.

[0128] Heating

[0129] The discovered WCT is especially suited for applications to generate heat. Heat generation may be performed using the WCT in both industrial and domestic applications. In the case of heating a gas or a liquid, the heat energy of the WCT can be effectively transferred via any heat exchange equipment as is known in the art of heat transfer.

[0130] In the case of heating air, it is most preferred that the exhaust of combustion be discharged directly into said air to be heated. In the case of heating air to be used in an enclosed human, plant and/or animal application, wherein the combustion components are at least one of: $O_2$ and $H_2$; and $O_2$, $H_2$ and $H_2O$, it is most preferred that at least a portion of the exhaust of combustion discharge directly into said air, thereby providing humidified heated air.

[0131] In the case of heating water, it is most preferred that the exhaust of combustion discharge directly into said water to be heated, wherein the water heater or hot water storage has a vent to release generated $NO_X$. In the case of heating water, wherein the combustion components are at least one of: $O_2$ and $H_2$; and $O_2$, $H_2$ and $H_2O$, it is most preferred that the exhaust of combustion can be discharged directly into said water to be heated, and wherein the water heater or hot water storage has a pressure relief device, as is known in the art.

[0132] It is most preferred in heating applications that the WCT create electricity, as well as heat the subject gas and/or liquid. Configurations for the heating of a gas or a liquid are limited to the creativity of the designer; however, configurations approximating the WCT, wherein the heating of a gas or a liquid is performed is approximated in **FIGS. 2 through 18**, wherein heat transfer can be performed either in the exhaust of said combustion or in the block of said WCT (CE). (In this case cooling said CE is not a loss of efficiency since the removed heat has a purpose.)

[0133] Cooling

[0134] The discovered WCT is especially suited for applications to remove heat. Heat removal may be performed using the WCT, wherein at least one of: cryogenic distillation is performed and/or the WCT provides mechanical energy, wherein said mechanical energy powers a refrigeration system. In the case of cooling a gas or a liquid, the heat sink capability of the chilled $N_2$ from said cryogenic distil-

lation is preferably transferred via heat exchange equipment, as is known in the art of heat transfer. In the case of cooling a gas or a liquid, a refrigeration unit is preferably used, wherein said refrigeration unit is powered by energy is created by the WCT.

[0135] In the case of cooling air or water, it is most preferred that the heat sink capability of the chilled $N_2$ from said cryogenic distillation be transferred either directly to said air and/or via any heat exchange technology as is known in the art of heat transfer.

[0136] It is most preferred in cooling applications that the WCT create electricity, as well as cool a gas and/or liquid. System configurations for the cooling of a gas or a liquid are limited to the creativity of the designer.

[0137] Water Chemistry

[0138] Water is the most efficient and economical method of storing $O_2$ and/or $H_2$. Electrolysis of water is the preferred method of converting stored $H_2O$ into combustible $H_2$ and/or $O_2$. Electrolysis is best performed with a dissolved electrolyte in the water; the dissolved electrolyte, most preferably a salt, will improve conductivity in the water, thereby reducing the required electrical energy to perform electrolysis. It is an embodiment to perform electrolysis upon water that contains an electrolyte. It is preferred to perform electrolysis upon water that contains a salt. It is most preferred to perform electrolysis upon water that contains polyelectrolytes. However, many dissolved cation(s) and anion(s) combination(s) can precipitate over time reducing the efficiency of electrolysis. Due to inherent solubility, it is a preferred embodiment to perform electrolysis upon water that contains a Group IA/Group VIIA salt (including acids). Further, as temperature is increased, hard water contaminants may precipitate; therefore, it is preferred that the water of electrolysis be distilled or de-ionized prior to the addition of a Group IA/Group VIIA salt. Since electrolytic processes create heat, it is preferred to cool electrolysis. It is most preferred to cool electrolysis with the available heat sink from the $N_2$ available from the cryogenic distillation of air.

[0139] A dispersant is preferably added to water to prevent scale. Dispersants are low molecular weight polymers, usually organic acids having a molecular weight of less than 25,000 and preferably less than 10,000. Dispersant chemistry is based upon carboxylic chemistry, as well as alkyl sulfate, alkyl sulfite and alkyl sulfide chemistry; it is the oxygen atom that creates the dispersion, wherein oxygen takes its form in the molecule as a carboxylic moiety and/or a sulfoxy moiety. Dispersants that can be used which contain the carboxyl moiety are, but are not limited to: acrylic polymers, acrylic acid, polymers of acrylic acid, methacrylic acid, maleic acid, fumaric acid, itaconic acid, crotonic acid, cinnamic acid, vinyl benzoic acid, any polymers of these acids and/or any combination therein. Dispersants that can be used contain the alkyl sulfoxy or allyl sulfoxy moieties include any alkyl or allyl compound, which is water soluble containing a moiety that is at least one of: SO, $SO_2$, $SO_3$, and/or any combination therein. Due to the many ways in which an organic molecule can be designed to contain the carboxyl moiety and/or the sulfoxy moiety, it is an embodiment that any water soluble organic compound containing at least one of a carboxylic moiety and/or a sulfoxy moiety. (This is with the knowledge that not all dispersants have equivalent dispersing properties.) Acrylic polymers exhibit very good dispersion properties, thereby limiting the deposition of water soluble salts and are most preferred embodiments as a dispersant. The limitation in the use of a dispersant is in the dispersants water solubility in combination with its carboxylic nature and/or sulfoxy nature.

[0140] Water is inherently corrosive to metals. Water naturally oxidizes metals, some with a greater oxidation rate than others. To minimize corrosion, it is preferred that the water have a pH of equal to or greater than 7.5, wherein the alkalinity of the pH is from the hydroxyl anion. Further, to prevent corrosion or deposition of water deposits on steam turbines, it is preferred to add a corrosion inhibitor to the water. It is an embodiment to utilize nitrogen containing corrosion inhibitors, such as hydrazine, as is known in the art.

[0141] Corrosion inhibitors are added to water to prevent corrosion. Chelants can be used to prevent corrosion, as well as complex and prevent the deposition of many cations, including hardness and heavy metals. Chelants or chelating agents are compounds having a heterocyclic ring wherein at least two kinds of atoms are joined in a ring. Chelating is forming a heterocyclic ring compound by joining a chelating agent to a metal ion. Chelants contain a metal ion attached by coordinate bonds (i.e. a covalent chemical bond is produced when an atom shares a pair of electrons with an atom lacking such a pair) to at least two nonmetal ions in the same heterocyclic ring. Examples of the number of chelants used for mineral deposition in the present invention are water soluble phosphates consisting of phosphate, phosphate polymers, phosphate monomers and/or any combination thereof. The phosphate polymers consist of, but are not limited to, phosphoric acid esters, metaphosphates, hexametaphosphates, pyrophosphates and/or any combination thereof. Phosphate polymers are particularly effective in dispersing magnesium silicate, magnesium hydroxide and calcium phosphates. Phosphate polymers are particularly effective at corrosion control. With proper selection of a polymer, along with maintaining an adequate polymer concentration level, the surface charge on particle(s) can be favorably altered. In addition to changing the surface charge, polymers also function by distorting crystal growth. Chelants lock the metals in the water into soluble organic ring structures of the chelants. Chelants provide reactive sites that attract coordination sites (i.e. areas of the ion that are receptive to chemical bonding) of the cations. Iron, for example, has six coordination sites. All coordination sites of the iron ion are used to form a stable metal chelant. Chelants combine with cations such as calcium, magnesium, iron and copper that could otherwise form deposits. The resulting chelated particles are water soluble. The effectiveness of chelant(s) is limited by the concentration of competing anions, alkalinity and temperature.

[0142] The effect of adding sufficient amounts of the number of chelant(s) by the WCT is to reduce available free metal ions in the water and therefore, reduce the phosphate demand. Phosphate, such as phosphoric acid and/or pyrophosphoric acid is used to complex or form metal phosphates, which are insoluble. In the preferred embodiments, phosphate polymers, such as metaphosphate and/or hexametaphosphate is used as a corrosion inhibitor and as a chelant to prevent correspondingly any precipitation of calcium and/or magnesium, while providing corrosion control. Meta-

phosphate and/or hexametaphosphate, as well as polymers based upon this chemistry, soften the water by removing the free calcium and/or magnesium ions from the water and by bringing the metal ions into a soluble slightly-ionized compound or radical. In addition, the water containing any excess metaphosphate and/or hexametaphosphate will actually dissolve any phosphate or carbonate which may deposit. Metaphosphate and/or hexametaphosphate do not throw the metal ions out of solution as is the case of usual water softening compounds, but rather lock up the metal ions in a metaphosphate and/or a hexametaphosphate complex molecule; these molecules provide a one or two molecule thickness coating on metal surfaces to limit metal corrosion. This is particularly important for heavy metal materials.

[0143] Operating Pressure Relief

[0144] The WCT will have applications wherein the recycling or uses of the exhaust gasses of combustion create high operating pressures. Further, it is very feasible that there may be unintended operating situations, wherein the operating pressure becomes greater than the design pressure of the equipment employed; any such situation can be a significant safety issue. In the case of the internal combustion engine, a significant industry paradigm shift may be required for the industry to even consider trapping and recycling combustion engine exhaust gases. The discovered WCT will contain at least one of: $H_2$, $N_2$, $O_2$, $H_2O$ and/or any combination therein at various pressures in many aspects of the invention. To ensure that the WCT operate safely, in the event of an equipment operating failure or of equipment operating in excess of the intended pressure, pressure relief is preferred. Pressure relief can limit the potential event of a catastrophic failure. It is preferred that pressure relief device(s) be installed throughout the WCT as those devices are known in the art and as are normally located via a Failure Mode and Effect Analysis and/or a Fault Tree Analysis. Example devices include pressure relief valves, rupture discs and pressure relief control loops. It is most preferred that a pressure relief device be installed downstream of any compression generating portion of the WCT. As such, it is most preferred that pressure relief device(s) be installed immediately downstream of any compressor and in the combustion engine exhaust. **FIGS. 2 through 18** approximate the location of pressure control/relief in the combustion engine exhaust. **FIG. 24** approximates pressure relief designs.

[0145] WCT Engine and Apparatus

[0146] Referring to **FIGS. 3 through 18**, a combustion engine (CE) is symbolically shown for receiving as fuel $H_2$ and at least one of: $O_2$ and air. Said combustion engine may be of any type, wherein combustion is performed to generate at least one of: mechanical torque, heat, thrust, electricity and/or any combination therein. It is preferred that $H_2O$ be received in the combustion chamber, along with said fuel, said $H_2O$ in the combustion chamber is to be termed combustion $H_2O$.

[0147] $H_2$ flowing to CE is to have a flow. $O_2$ flowing to CE to have a flow. Air flowing to CE is to have a flow. Means to measure said $H_2$ flow, measure said $O_2$ flow and measure said air flow are to be provided such that a proportional signal in relation to flow is sent to the CE controller (CONT) from each of said $H_2$ flow measuring device, said $O_2$ flow measuring device and said air flow measuring device. $H_2$ flowing to CE is to have flow valve(s). $O_2$ flowing to CE to have flow control valve(s). Air flowing to CE is to have flow control device(s) in the form of a valve or a compressor. CONT is to have as input said $H_2$ flow signal, said $O_2$ flow signal and said air flow signal. Said controller is to receive an input signal from an external source indicating the combustion setpoint. Said controller is to compare said combustion setpoint to said $H_2$ flow signal, sending a proportional signal to said $H_2$ flow control valve that is in proportion to the difference in the combustion setpoint and the $H_2$ flow signal, thereby proportioning said $H_2$ flow control valve. CONT is to compare said $O_2$ flow signal and said air flow signal to an $H_2/O_2$ ratio setpoint, providing a proportional signal to an $O_2$ flow control valve and to an air flow control device, wherein: said $H_2$ flow, said $O_2$ flow and said air flow are such that the molar ratio of $H_2/O_2$ is approximately 2:1. In the case wherein said $O_2$ flow control valve signal is not near approximately 100%, CONT sends a signal to close said air flow control device. In the case wherein said $O_2$ flow control valve signal is near approximately 100%, CONT compares said $O_2$ flow signal and said air flow signal to said $H_2/O_2$ ratio setpoint obtaining an air flow difference, sending a proportional signal to said air flow control device that is in proportion to said difference, thereby proportioning said air flow control device.

[0148] To conserve energy, as depicted in **FIG. 20**, it is preferred that the $H_2$ flow control valve(s) consist of a two staged system of flow control valves. The first $H_2$ flow control valve, downstream of generated $H_2$ and downstream of $H_2$ storage is to control $H_2$ flow to CE. The second $H_2$ flow control valve (for installations that have generated $H_2$) is to be located from the generated $H_2$ line and be located in the $H_2$ line flow from $H_2$ storage. The second $H_2$ flow control valve is to remain closed until the first $H_2$ control valve is near approximately 100% open (thereby assuring full usage of generated $H_2$ prior usage of stored $H_2$) at which time the second $H_2$ flow control valve will begin opening to supply $H_2$ from storage.

[0149] To conserve energy, as depicted in **FIG. 20**, it is preferred that the $O_2$ flow control valve(s) consist of two staged flow control valves. The first $O_2$ flow control valve, downstream of generated $O_2$ and downstream of $O_2$ storage is to control $O_2$ flow to CE. The second $O_2$ flow control valve is to be located from the generated $O_2$ line and be located in the $O_2$ line flow from $O_2$ storage. The second $O_2$ flow control valve is to remain closed until the first $O_2$ control valve is near approximately 100% open (thereby assuring full usage of generated $O_2$ prior usage of stored $O_2$) at which time the second $O_2$ flow control valve will begin opening to supply $O_2$ from storage.

[0150] It is preferred that said combustion $H_2O$ have flow to said combustion chamber(s) in CE. It is preferred that a source of coolant flow to and/or through the block of CE. It is preferred that a temperature measurement device have a means of measuring combustion temperature and/or CE block temperature near the combustion chamber(s) of CE. Means to measure said combustion $H_2O$ flow and measure said combustion temperature are to be provided such that a proportional signal is sent to a controller (CONT) from each of said combustion $H_2O$ flow measuring device and said combustion temperature measuring device. CONT is to have as input said combustion $H_2O$ flow signal, afore said $H_2$ flow signal and said temperature signal. It is preferred that CONT

have a hot temperature setpoint, a coolant temperature setpoint, a warm temperature setpoint and an $H_2/H_2O$ ratio setpoint. It is preferred that CONT compare afore said $H_2$ flow signal and said combustion $H_2O$ flow signal to said $H_2/H_2O$ ratio setpoint, in combination with comparing said temperature signal to said warm temperature setpoint, said coolant temperature setpoint, said hot temperature setpoint and provide a proportional signal to said combustion $H_2O$ flow control vale and to said coolant flow control valve.

[0151] In the case wherein said temperature signal is less than said warm temperature setpoint, less than said coolant temperature setpoint and less than said hot temperature setpoint, it is preferred that CONT send a signal to said coolant flow control valve to close said coolant flow control valve; and send a signal to said combustion $H_2O$ flow control valve to close said combustion $H_2O$ flow control valve.

[0152] In the case wherein said temperature signal is equal to or greater than said warm temperature setpoint, less than said coolant temperature setpoint and less than said hot temperature setpoint, it is preferred that CONT send a signal to said coolant flow control valve to close said coolant flow control valve; and send a signal to said combustion $H_2O$ flow control valve, wherein said signal is proportional to the difference between said measured temperature signal and the warm temperature setpoint, and wherein the $H_2/H_2O$ ratio is greater than said $H_2/H_2O$ ratio setpoint, thereby proportioning said combustion $H_2O$ flow control valve.

[0153] In the case of said temperature signal greater than said warm temperature setpoint, equal to or greater than said coolant setpoint and less than said hot temperature setpoint, it is preferred that CONT send a signal to the combustion $H_2O$ flow control valve, wherein the $H_2/H_2O$ ratio is equal to said $H_2/H_2O$ ratio setpoint, thereby proportioning said combustion water flow control valve; and send a signal to said coolant flow control valve, wherein said signal is proportional to the difference between said temperature signal and said coolant setpoint, thereby proportioning said coolant flow control valve.

[0154] In the case wherein the temperature signal is greater than said warm temperature setpoint, greater than said coolant setpoint and equal to or greater than said hot temperature setpoint, it is preferred that CONT send a signal to open the combustion $H_2O$ flow control valve 100%, which obtains a $H_{21}H_2O$ ratio less than said $H_2/H_2O$ setpoint; and send a signal in proportion to the difference between the temperature signal and said coolant setpoint to said coolant flow valve, thereby proportioning said coolant flow control valve; and send a signal to said $H_2$ flow control valve, thereby closing said $H_2$ flow control valve; and send a signal to said $O_2$ flow control valve, thereby closing said $O_2$ flow control valve; and send a signal to said air flow control device, thereby closing said air flow control device.

[0155] It is most preferred that the WCT Engine operate at a temperature between said warm temperature setpoint and said coolant temperature setpoint. It is preferred that energy not leave the WCT engine via coolant. It is most preferred that required engine cooling be performed by the addition of combustion $H_2O$ to the combustion chamber(s).

[0156] Said WCT Engine is to preferably obtain $O_2$ from at least one of: $O_2$ storage, cryogenic distillation, membrane separation, PSA, electrolysis of $H_2O$ and/or any combination therein. Said cryogenic distillation is to obtain $O_2$ from at least one of air and/or electrolysis of $H_2O$. Said membrane separation and/or said PSA is preferably to obtain $O_2$ from air. Said cryogenic distillation and/or said membrane separation and/or said PSA is to preferably be powered by said WCT Engine. Said $O_2$ storage is to preferably be performed at cryogenic temperatures. The mechanical energy for said cryogenic storage is preferably created by said WCT Engine.

[0157] Said WCT Engine is preferably to obtain $H_2$ from at least one of: $H_2$ storage, steam corrosion of a metal(s), electrolysis of $H_2O$ and/or any combination therein. Said steam, to produce $H_2$ from said corrosion, is preferably an exhaust product of said WCT Engine. Said $H_2$ storage is to preferably be performed at cryogenic temperatures. The mechanical energy for said cryogenic storage is preferably created by said WCT Engine.

[0158] Afore said electrolysis of $H_2O$ is preferably to obtain electrical energy for electrolysis from a generator driven by at least one of: a steam turbine, mechanical rotating energy, an air turbine powered by the energy of moving air, a water turbine powered by the energy of moving water and/or any combination therein and/or photovoltaic cell(s). It is preferred that said electrical energy be regulated. In the case wherein an alternator or dynamo is used, it is preferred that said electrical energy be converted from an alternating current to a direct current. Said steam turbine is most preferably powered by steam generated by afore said WCT Engine. Said mechanical rotating energy is preferably powered by afore said WCT Engine.

[0159] The WCT Engine is to preferably generate mechanical energy in the form of torque. It is preferred that said mechanical energy turn a generator, wherein said generator create electrical energy. Exhaust from said WCT Engine is preferably to turn a steam turbine, wherein said steam turbine turns a generator, wherein said generator creates electrical energy. It is preferred that at least a portion of said electrical energy is used to electrolytically convert $H_2O$ into $H_2$ and $O_2$. It is most preferred to use a portion of said $H_2$ and/or said $O_2$ as fuel for said WCT Engine.

[0160] Materials of construction for the WCT Engine, the fuel and energy management systems and apparatus are to be those as known in the art for each application as said application is otherwise performed in the subject art. For example, various composite and metal alloys are known and used as materials for use at cryogenic temperatures. Various composite and metal alloys are known and used as materials for use at operating temperatures of over 500° F. Various ceramic materials can be conductive, perform at operating temperatures of over 2,000° F., act as an insulator, act as a semiconductor and/or perform other functions. Various iron compositions and alloys are known for their performance in combustion engines that operate approximately in the 200 to 1,500° F. range. Titanium and titanium alloys are known to operate over 2,000 and 3,000° F. Tantalum and tungsten are known to operate well over 3,000° F. It is preferred to have at least a portion of the construction of the WCT Engine contain an alloy composition wherein at least one of: a period 4, period 5 and/or a period 6 heavy metal is used, as that metal(s) is known in the art to perform individually or to combine in an alloy to limit corrosion and/or perform in a cryogenic temperature application and/or perform in a temperature application over 1,000° F. While aluminum is lightweight and can perform limited structural applications, aluminum is limited in application temperature. Due to the operating temperatures involved in the WCT Engine, thermoplastic materials are not preferred unless the application of use takes into account the glass transition temperature and the softening temperature of the thermoplastic material.

EXAMPLE 1

[0161] A traditional gasoline internal combustion engine obtains approximately 20 miles per gallon. Performing an energy balance on the engine, according to FIG. 2:

$E_F = E_W + E_{EX} + E_C + E_{fric} + C_E$

$E_F$=20 mpg+~35% $E_F$+35% $E_F$+~9% $E_F$+1% $E_F$

$E_F = E_W$+~80% $E_F$ in energy losses for internal CE(s).

$E_F$=20 mpg+80% $E_F$; $E_F$=100 mpg and $E_W$~20% $E_F$

[0162] Again,

$E_F = E_W + E_{EX} + E_C + E_{fric} + C_E$

[0163] Assuming: 1) complete engine insulation, 2) a steam turbine with 80% efficiency, 2) a generator with 90% efficiency and 3) an electrolysis unit with 80% efficiency turns $E_X$ and $E_C$ together into approximately 30% $E_F$

[0164] Using WCT,

$E_F = E_W$+30% $E_F$+~9% $E_F$+~1% $E_F$

$E_F = E_W$+~40% $E_F$ (energy losses); $E_W(WCT)$=60% $E_F$

EXAMPLE 2

[0165] Referencing CRC Handbook of Chemistry and Physics, the total available combustion energy for n-Octane is approximately 1,300 kcal/mole; at 114 lb/lb mole $E_F$=11.4 kcal/g and at 454 g/lb. $E_F$=5176 kcal/lb. (This excludes endothermic losses in the formation of $NO_X$.) Further, the density of n-Octane is approximately 5.9 lb/gallon, which leads to energy figures for n-Octane in the average automobile:

[0166] $E_F$~100 mpg=17 mile/lb.=5176 kcal/lb.; $E_W$~20 mpg=3.4 mile/lb.=1143 kcal/lb. The total available energy for the combustion of hydrogen is 68 kcal/mole; at 2 lb/lb mole $E_F$=34 kcal/g=15436 kcal/lb. Therefore, on a mass basis, $H_2$=34/11.4~3 times more energy per pound.

[0167] Using WCT, 60%/20%=3 times more efficient. Correlating, energy figures for WCT in the average automobile:

[0168] First, the fuel availability must be calculated. $H_2$ is 100% as delivered. Since cryogenics are at least approximately 16% efficient, the production of $O_2$ is conservatively estimated to be 16% efficient.

⅔x1+⅓x0.16~70%

[0169] (Therefore, approximately 30% of the energy of the $H_2$ and $O_2$ is used to generate $O_2$.)

$$E_F \approx \frac{17\ \text{mile/lb. Octane} \times 0.70 \times 15436\ \text{kcal/lb. } H_2 \times 3}{5176\ \text{kcal/lb. n-Octane}} = 35.5\ \text{miles/lb. } H_2;\ E_W \approx 21.3\ \text{mile/lb. } H_2$$

$\left(\text{Note: Every mole of } H_2 \text{ requires } \frac{1}{2} \text{ mole of generated } O_2; \text{ therefore, at } STP \text{ every psig of } H_2 \text{ requires 0.5 psig of } O_2.\right)$

EXAMPLE 3

[0170] According to the Chemical Market Reporter, $H_2$ has a market price of approximately $0.50/lb. and gasoline has a price of approximately $1.60 per gallon or approximately $0.27 per pound. Utilizing traditional hydrocarbon combustion technology in transportation, the cost per mile for fuel is:

[0171] $0.27 per lb./3.4 mile per lb.=$0.08 per mile for gasoline

[0172] Utilizing the WCT with $0.50/lb. $H_2$, the cost per mile for fuel is:

[0173] $0.50 per lb./21.3 mile per lb.=$0.023 per mile

[0174] (This calculation can be altered to the current market price of hydrogen.)

EXAMPLE 4

[0175] Electrical power plants currently produce electricity using a natural gas turbine followed by a steam turbine, wherein the energy for steam generation is transferred via a boiler from the exhaust gas of the natural gas turbine. As is typical in the industry:

[0176] The efficiency of combustion is approximately 99 percent.

[0177] The efficiency of the natural gas turbine is approximately 20 percent.

[0178] The efficiency of the boiler is approximately 85 percent.

[0179] The efficiency of the steam generator is approximately 90 percent.

[0180] Utilizing the above, the efficiency of electricity generation is approximately:

0.99x0.20+0.99x0.20x0.85x0.90=35 percent

[0181] For WCT utilizing the combustion/steam turbine configuration in FIG. 23A, appropriate assumptions for efficiency would be approximately:

[0182] The efficiency of combustion near 99 percent.

[0183] The efficiency of $O_2$ generation (cryogenics at least 16%) near 16 percent.

[0184] Hydrogen is delivered, thereby having 100% delivery efficiency.

[0185] Heat loss of water at exhaust ((1200° F.−212° F.)/1200° F.)~80% percent.

[0186] Friction losses near 12 percent.

[0187] Utilizing the above, the efficiency of electricity generation is approximately:

0.99x(⅔x1+⅓x0.16)x0.80x0.88~50 percent

[0188] (This can be improved if the final steam turbine operates at less than atmospheric pressure.)

[0189] Utilizing the above, incorporating:

[0190] An $H_2$ price of approximately $0.50 per pound.

[0191] A natural gas price of approximately $6.00 per thousand cubic feet.

[0192] A natural gas energy value of approximately 212 kcal/mole.

[0193] The cost of electricity production for WCT on a kcal basis is:

(15436 kcal/lb. $H_2$)x(lb. $H_2$/$0.50)x0.50=15436 kcal/$

[0194] The cost of electricity production for a traditional natural gas plant on a kcal basis is:

[0195] First convert cubic feet to pounds at STP and convert to kcal/lb.:

1000 cubic feet (tcf)/360 cubic feet per lb. mole=2.78 lb. mole

[0196] 2.78 lb. mole×16 lb./lb. mole=44.5 lb. gas; \$6.00/44.5 lb. gas=\$0.135/lb. gas

[0197] (212 kcal/mole×454 mole/lb. mole gas)×(lb. mole gas/16 lb. gas)=6016 kcal/lb. gas

[0198] Second, estimate economics:

(6016 kcal/lb. gas)×(lb. gas/\$0.135)×0.35=15784 kcal/\$

### EXAMPLE 5

[0199] In residential heating, natural gas is often used. Referencing above, the cost of natural gas heating, assuming 80% heat transfer efficiency is:

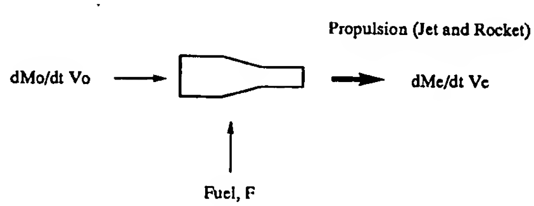
(\$8.00 per tcf/45 lb. per tcf)×0.80/13.25 kcal/lb.=\$0.011/kcal

[0200] For WCT using membranes and referencing above with 40% efficiency:

\$0.50/lb.×(⅔×1+⅓×0.40)×0.80/34 kcal/lb.=\$0.009/kcal

### EXAMPLE 6

[0201]




Flow Diagram 2

Thrust=Force=$F=dMe/dt\ Ve-dMo/dt\ Vo$; Let $Me=Mo+M_F$,

[0202] wherein $M_F$=mass of fuel.

$F={}_{t0}\int^{t1}{}_{Vo}\int^{Ve} Me-Mo={}_{t0}\int^{t1}{}_{Vo}\int^{Ve} Mo+M_F-Mo={}_{t0}\int^{t1}{}_{Vo}\int^{Ve} M_F$

For WCT, $F_{WCT}={}_{t0}\int^{t1}{}_{Vo}\int^{Ve}\{M_{H2}+M_{O2}+M_{H2O}\}$; $F_{Kerosene}=F_K={}_{t0}\int^{t1}{}_{Vo}\int^{Ve}\{M_K+M_{O2}\}$

[0203] Assuming the same time integration and the same thrust velocity integration, then the comparison for thrust can be written as:

Is, $F_{WCT}\geqq F_K$ ? And, therefore, Is $\{M_{H2}+M_{O2}+M_{H2O}\}\geqq\{M_K+M_{O2}\}$?

And, then is $\{M_{H2}+M_{H2O}+M_{Air}\}\geqq\{M_K+M_{Air}\}$?

And, then is $\{M_{H2}+M_{H2O}\}\geqq\{M_K\}$?

And, then is $\{M_{H2}+M_{Air}\}\geqq\{M_K+M_{Air}\}$?

[0204] $\Delta H_{H2}$=51,571 BTU/lb., $\Delta H_K$=19,314 BTU/lb.,

| | |
|---|---|
| $H_2$ + ½ $O_2$ → $H_2O$ | $C_{14}H_{30}$ + 4½ $O_2$ → 14 $CO_2$ + 15 $H_2O$ |
| 1 lb. + 8 lb. → 9 lb. | 1 lb. + 3.47 lb. → 3.11 lb. + 1.36 lb. |

[0205] $Cp_K$=0.6 BTU ° F./lb., $Cp_{H2O}$~0.46 BTU ° F./lb., $Cp_{H2}$=3.45 BTU ° F./lb.,

[0206] $Cp_{Air}$=0.46 BTU ° F./lb.; $\Delta H_{V,H2O}$=974 BTU/lb., $\Delta H_{F,H2O}$=144 BTU/lb.,

[0207] Kerosene(K) a liquid, $H_2$ vaporized by ambient temperature

[0208] Assuming stochiometric air and thereby the same combustion exhaust temperature~1000° F., then there is approximately 1000° F. temperature differential to combustion temperature. (Note air is 18% $O_2$.) Doing an energy balance:

[0209] ΔH Combustion=ΣΔH's

[0210] $\Delta H_K=Cp_K$(lb. K)(1000)+$Cp_{AIR}$(3.47/0.18)(1000)+$Cp_{AIR}$(lb. AIR)(1000)

[0211] 19,314=(0.6)(1)(1000)+0.46(3.47/0.18)(1000)+0.46(lb. Air)(1000)

[0212] ∴19,314=600+8868+460(lb. Air), Air (cooling)=21 lb., Total air=21+3.47/0.18=40.3 lb.

[0213] ∴ For K, 1 lb. K/40.3 lb. air=41.3 lb. thrust@1000° F. (40.3 lb. air/lb. K~1000 ft.$^3$ air/lb. K)

[0214] $\Delta H_{H2}$=3.45(1)(1000)+0.46(8/0.18)(1000)+0.46(lb. $H_2O$)(1000)+974(lb. $H_2O$)

[0215] 51,571=3450+20,444+1434(lb. $H_2O$), $H_2O$ cooling =19.3 lb., Air=8/0.18=44.4 lb.

[0216] ∴For $H_2$, 1 lb. $H_2$/44.4 lb. air/19.3 lb. $H_2O$=64.7 lb. thrust. (Note this design requires a 10% increase in intake air compression system capability while maintaining 1000° F. exhaust temperature.) If the same air is used with no $H_2O$ cooling, then the fuel is reduced by 19,314/51,571=0.374, 19,314=3.45(0.374)(1000)+0.46(8/0.18)(0.374)(1000)+0.46(lb. Air)(1000), Air (cooling)=22.6 lb.; Air combustion=8(0.374)/0.18=16.62 lb., total air=39.22 lb.

[0217] ∴ For $H_2$ w/air cooling, 0.37 lb. $H_2$/39.22 lb. Air=39.6 lb. Thrust, a 5% reduction @ 1000° F. (39.22 lb. air/0.37 lb. $H_2$=106 lb. air/lb. $H_2$~2630 ft.$^3$ air/lb. $H_2$. (Note this design requires a 160% increase in intake air compression system capability to maintain 1000° F. exhaust temperature.)

[0218] ∴ Previous issues with $H_2$ are $H_2$ requires 160% more air per pound than Kerosene to burn at the same temperature. $H_2$ requires an air increase/air compressor capability increase to perform similar to Kerosene

[0219] Evaluation of Alternative Propulsion Options:

[0220] Sg of Liquid $H_2$=0.07; Sg of Liquid $O_2$=1.14; Sg of $H_2O$=1.00; Sg of K=0.80

[0221] 0.8/0.07=11.4 times the volume; however at (51,571/19,314) 2.67 times the energy, 11.4/2.67=4.27 times the volume, say 4.3 times the volume.

[0222] While every lb. of $H_2O$ equals a lb. of thrust, there is no thrust multiplication effect for the $H_2O$, as there is with fuel. There is a benefit to create a hydrogen gel with $H_2O$ instead of the currently produced hydrogen methane gel. However, ice sublimation energy will slightly reduce thrust:

[0223] 19,314=3.45(0.374)(1000)+0.46(8/0.18)(0.374)(1000)+0.46(lb. Air)(1000)+144(0.0374)+0.46 (0.0374)(1000)

[0224] 10,355=460(lb. Air, Air (cooling)=22.5 lb.

[0225] ∴ Thrust=22.5+8/0.18(0.374)+0.374+0.0374=39.5 lb.

[0226] Moving to $H_2$ and $O_2$ Systems w/Air Cooling:

[0227] 51,571=3.45(1)(1000)+0.44(8)(1000)+0.46 (lb. Air)(1000), Air (cooling)=97 lb.

[0228] ∴ Thrust=105 lb., lb. Thrust/lb. fuel=105/9=11.67

[0229] Moving to $H_2$ and $O_2$ Systems with $H_2O$ Cooling:

[0230] 51,571=3.45(1)(1000)+0.44(8)(1000)+0.46 (lb. $H_2O$)(1000)+144(lb. $H_2O$)

[0231] ∴ $H_2O$ (cooling)=73 lb.

[0232] ∴ Thrust=82 lb., lb. Thrust/lb. fuel=1.0

[0233] Both systems with $O_2$ could contain an $O_2$ gel with $H_2O$ as the frozen component. In all WCT applications, $H_2$ could be a $H_2$ gel with $H_2O$ as the frozen component. In rocket applications, the hydrogen could be mixed with frozen water and with frozen oxygen to create a hydrogen/oxygen/water gel. The molar ration of $H_2/O_2$ would be preferably 2, and the amount of water in the gel would depend on the cooling desired versus the acceptable explosivity of the gel. (Extremely explosive mixture.) Hydrogen has a wide combustion window, approximately 5 to 90% in air.

[0234] Preferred Embodiments

[0235] 1. Preferred operation is $H_2$ with air while stoichiometically increasing the jet air intake for $H_2$ thermodynamics and/or to operate with excess air for cooling.

[0236] 2. To increase thrust, $H_2$ with $O_2$ and excess air cooling is most preferred. To increase thrust $H_2$, $O_2$ with $H_2O$ is preferred.

[0237] 3. It is preferred to use $H_2$ and air at altitudes wherein there is enough air available. $H_2$, $O_2$ and air is preferred at moderate altitudes and high altitudes. $H_2$, $O_2$ and $H_2O$ is preferred at all altitudes and most preferred at very high altitudes, such as in a space plane application.

[0238] 4. $H_2$, $O_2$ and air is preferred in after burn or high thrust situations, thereby increasing thrust capability upwards of 150% over that available with K or $H_2$ combined with air.

[0239] 5. $H_2O$ is preferred to cool exhaust, thereby reducing the WCT heat signature and the ability of a heat seeking missile to find the WCT.

[0240] Certain objects are set forth above and made apparent from the foregoing description. However, since certain changes may be made in the above description without departing from the scope of the invention, it is intended that all matters contained in the foregoing description shall be interpreted as illustrative only of the principles of the invention and not in a limiting sense. With respect to the above description, it is to be realized that any descriptions, drawings and examples deemed readily apparent and obvious to one skilled in the art and all equivalent relationships to those described in the specification are intended to be encompassed by the present invention.

[0241] Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention. It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall in between.

**1-215.** (canceled)

**216.** An engine comprising a fuel mixture of oxygen and hydrogen, wherein

combustion temperature is at least partially controlled with the addition of water to combustion.

**217.** The engine of claim 216, wherein mechanical rotating energy is created.

**218.** The engine of claim 217, wherein said rotating mechanical energy turns a generator to create electrical energy.

**219.** The engine of claim 216, wherein the steam produced by combustion turns a generator to create electrical energy.

**220.** The engine of claim 216, wherein heat is created.

**221.** (canceled)

**222.** The engine of claim 218 or 219, wherein at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and oxygen is at least a portion of said fuel mixture.

**223.** The engine of claim 216, wherein nitrogen or argon is in said fuel mixture.

**224.** The engine of claim 216, wherein said fuel mixture comprises air.

**225.** The engine of claim 216, wherein at least a portion of the steam produced by combustion is converted to hydrogen by the corrosion of at least one metal.

**226.** The engine of claim 225, wherein the conversion of said steam into said hydrogen is increased by an electrical current in said metal(s).

**227.** The engine of claim 225 or 226, wherein said hydrogen is at least a portion of the hydrogen in said fuel mixture.

**228.** The engine of claim 216, wherein a generator turns due to the movement of air or water, and wherein

said generator creates electrical energy, and wherein

said electrical energy is at least partially utilized in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and said oxygen is at least a portion of said fuel mixture.

229. The engine of claim 216, wherein a photovoltaic cell creates electrical energy, and wherein

said electrical energy is at least partially used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and said oxygen is at least a portion of said fuel mixture.

230. The engine of claim 216, incorporating a cryogenic air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said cryogenic air separation unit.

231. The engine of claim 230, wherein the nitrogen separated from air in said cryogenic air separation unit is used to cool any portion of at least one selected from a list consisting of: said cryogenic air separation unit, the storage of oxygen, the storage of hydrogen, electrolysis, coolant for said engine, said engine and any combination thereof.

232. The engine of claim 230, wherein the nitrogen separated from air in said cryogenic air separation unit is at least partially used to cool air or water.

233. The engine of claim 216, incorporating a membrane air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said membrane air separation unit.

234. The engine of claim 216, incorporating a PSA air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said PSA air separation unit.

235. The engine of claim 230, 233 or 234, wherein the oxygen separated from air is at least one of enriched oxygen, pure oxygen and very pure oxygen.

236. The engine of claim 230, 233 or 234, wherein at least a portion the oxygen separated from air is at least a portion of said fuel mixture.

237. The engine of claim 216, wherein at least one selected from a list consisting of a: corrosion inhibitor, chelant, dispersant and any combination therein is added to the water in said engine.

238. The engine of claim 216, wherein said engine performs at least one of: internal, turbine and heating combustion.

239. The engine of claim 216, wherein at least one of oxygen and hydrogen is stored in at least one of a cooled gas state and a liquid state by liquefaction.

240. The engine of claim 239, wherein the compressor(s) for at least one of cooling and liquefaction is powered by at least one of said engine and a fuel cell.

241. The engine of claim 240, wherein said fuel cell is powered by hydrogen and at least one of oxygen and air.

242. The engine of claim 216, wherein at least one of said hydrogen and oxygen is stored in a mixture with frozen water crystals to form a gel.

243. The engine of claim 216, wherein at least one selected form a list consisting of: hydrogen, oxygen and water are preheated prior to combustion with the energy from at least one selected from a list consisting of: ambient temperature, said engine, said engine exhaust, an electrical radiant heat source and any combination therein.

244. The engine of claim 217, wherein said mechanical rotating energy from said engine enters a transmission, wherein

said transmission engage in a manner that is inversely proportional to at least one of the torque and work output of said engine, and wherein

said transmission output mechanical rotating energy turn a generator to create electrical energy.

245. The engine of claim 244, wherein said transmission engage a flywheel capable of storing rotational kinetic energy, wherein

said flywheel turns said generator.

246. The engine of claim 244, wherein at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen.

247. The engine of claim 246, wherein at least one of said hydrogen and oxygen is at least a portion of said fuel mixture.

248. The engine of claim 216 or 219, wherein a pressure control device is in said engine exhaust.

249. The engine of claim 216, wherein at least one of combustion heat energy and engine exhaust energy is used to heat at least one of a gas and a liquid.

250. The engine of claim 249, wherein at least one of the gas is air and the liquid is water.

251. The engine of claim 250, wherein said exhaust discharge directly into said air or water.

252. The engine of claim 216 or 230, wherein said engine is insulated.

253. The engine of claim 230, wherein hydrogen is separated.

254. The engine of claim 216, wherein said oxygen is at least one of: enriched oxygen, pure oxygen and very pure oxygen.

255. (canceled)

256. The engine of claim 216, wherein the temperature of combustion is at least partially controlled with air to combustion in excess over that required to perform combustion, wherein said excess air reduces at least one of the combustion temperature and the formation of nitrogen oxide(s).

257. The engine of claim 256, wherein there is no water addition to combustion.

258. The engine of claim 216, wherein the temperature of said engine exhaust is at least partially cooled with water.

259. The engine of claim 256, 257 or 258, comprising jet propulsion.

260. The engine of claim 216, 254, 266, 257 or 258, comprising rocket propulsion.

261. A method of performing combustion comprising a fuel mixture of oxygen and hydrogen, wherein

said oxygen is at least one of: enriched oxygen, pure oxygen and very pure oxygen.

262. The method of claim 261, wherein water is added to combustion.

263. The method of claim 261, wherein mechanical rotating energy is created.

264. The method of claim 263, wherein said rotating mechanical energy turns a generator to create electrical energy.

265. The method of claim 261, wherein the steam produced by combustion turns a generator to create electrical energy.

266. The method of claim 261, wherein heat is created.

267. (canceled)

268. The method of claim 264 or 265, wherein at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and oxygen is at least a portion of said fuel mixture.

269. The method of claim 261, wherein nitrogen or argon is in said fuel mixture.

270. The method of claim 261, wherein said fuel mixture comprises air.

271. The method of claim 261, wherein at least a portion of the steam produced by combustion is converted to hydrogen by the corrosion of at least one metal.

272. The method of claim 271, wherein said conversion of steam into said hydrogen is increased by an electrical current in said metal(s).

273. The method of claim 271 or 272, wherein said hydrogen is at least a portion of the hydrogen in said fuel mixture.

274. The method of claim 261, wherein a generator turns due to the movement of air or water, and wherein

said generator creates electrical energy, and wherein

said electrical energy is at least partially utilized in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and oxygen is at least a portion of said fuel mixture.

275. The method of claim 261, wherein a photovoltaic cell creates electrical energy, and wherein

said electrical energy is at least partially used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen and oxygen is at least a portion of said fuel mixture.

276. The method of claim 261, incorporating a cryogenic air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said cryogenic air separation unit.

277. The method of claim 276, wherein the nitrogen separated from air in said cryogenic air separation unit is used to cool any portion of at least one selected from a list consisting of: said cryogenic air separation unit, the storage of oxygen, the storage of hydrogen, electrolysis, coolant for said combustion, said combustion and any combination thereof.

278. The method of claim 276, wherein the nitrogen separated from air in said cryogenic air separation unit is at least partially used to cool air or water.

279. The method of claim 261, incorporating a membrane air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said membrane air separation unit.

280. The method of claim 261, incorporating a PSA air separation unit, wherein

at least a portion of the energy of combustion powers at least a portion of said PSA air separation unit.

281. The method of claim 276, 279 or 280, wherein the oxygen separated from air is at least one of enriched oxygen, pure oxygen and very pure oxygen.

282. The method of claim 276, 279 or 280, wherein at least a portion of the oxygen separated from air is at least a portion of said fuel mixture.

283. The method of claim 261, wherein at least one selected from a list consisting of a: corrosion inhibitor, chelant, dispersant and any combination therein is added to the water in said method.

284. The method of claim 261, wherein the said method performs at least one of: internal, turbine and heating combustion.

285. The method of claim 261, wherein at least one of said oxygen and said hydrogen is stored in at least one of a cooled gas state and a liquid state by liquefaction.

286. The method of claim 285, wherein the compressor(s) for at least one of cooling and liquefaction is powered by at least one selected from a list consisting of said combustion and a fuel cell.

287. The method of claim 286, wherein said fuel cell is powered by hydrogen and at least one of oxygen and air.

288. The method of claim 261, wherein at least one of said hydrogen and said oxygen is stored in a mixture with frozen water crystals to form a gel.

289. The method of claim 261, wherein at least one of: said hydrogen, said oxygen and water is preheated prior to combustion with the energy from at least one selected from a list consisting of: ambient temperature, said combustion, said combustion exhaust, an electrical radiant heat source and any combination therein.

290. The method of claim 262, wherein said mechanical rotating energy from said combustion enters a transmission, wherein

said transmission engage in a manner that is inversely proportional to at least one of the torque and work output of said combustion, and wherein

said transmission output mechanical rotating energy turn a generator to create electrical energy.

291. The method of claim 290, wherein said transmission engage a flywheel capable of storing rotational kinetic energy, wherein

said flywheel turns said generator.

292. The method of claim 290, wherein at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen.

293. The method of claim 292, wherein at least a portion of at least one of said hydrogen and said oxygen is at least a portion of said fuel mixture.

294. The method of claim 261, wherein a pressure control device is in said combustion exhaust.

295. The method of claim 261, wherein at least one of combustion heat energy and the exhaust energy of said combustion is used to heat at least one of a gas and a liquid.

296. The method of claim 295, wherein at least one of the gas is air and the liquid is water.

297. The method of claim 296, wherein said exhaust discharge directly into said air or water.

298. The method of claim 261 or 276, incorporating insulation of the method.

299. The method of claim 276, wherein hydrogen is separated.

300. The method of claim 261, wherein the temperature of combustion is at least partially controlled with air to combustion in excess over that required to perform combustion,

wherein said excess air reduces at least one of the combustion temperature and the formation of nitrogen oxide(s).

**301**. The method of claim 261, wherein the temperature of combustion exhaust is at least partially cooled with water.

**302**. The method of claim 261, 300 or **301**, comprising jet propulsion.

**303**. The method of claim 261, 300 or **301**, comprising rocket propulsion.

**304**. An apparatus performing combustion of oxygen and hydrogen; said apparatus comprising,

a. a fuel apparatus comprising:

i. a source of oxygen, an oxygen flow control valve and an oxygen flow sensing device sensing oxygen flow sending an oxygen flow signal proportional to oxygen flow to a controller,

ii. a source of hydrogen, a hydrogen flow control valve and a hydrogen flow sensing device sensing hydrogen flow sending a hydrogen flow signal proportional to hydrogen flow to a controller,

iii. a source of air, an air flow control device and an air flow sensing device sensing air flow sending an air flow signal proportional to air flow to a controller, and

iv. a temperature measurement device measuring at least one of combustion temperature or said apparatus temperature sending a temperature signal in proportion to said combustion temperature or said apparatus temperature to a controller.

b. a coolant apparatus comprising,

i. a source of coolant and a coolant flow control valve, and

ii. a source of combustion water flow to the combustion chamber, a combustion water flow control valve and a combustion water flow sensing device sensing combustion water flow sending a combustion water flow signal proportional to combustion water flow to a controller.

c. a control apparatus comprising at least one controller;

i. receiving said proportional flow signal for oxygen, hydrogen, air and combustion water,

ii. receiving said proportional temperature signal,

iii. receiving an external combustion signal set point,

iv. having a setpoint for the ratio of hydrogen to oxygen,

v. having a setpoint for the ratio of hydrogen to combustion water,

vi. having a warn temperature setpoint,

vii. having a coolant temperature setpoint, and

viii. having a hot temperature setpoint.

d. said control apparatus comparing said combustion signal setpoint to said hydrogen flow signal, sending a signal to the hydrogen flow control valve in proportion to the difference in said hydrogen flow signal to said combustion signal setpoint, thereby proportioning said hydrogen flow control valve.

e. said control apparatus comparing said hydrogen flow signal and said oxygen flow signal to the hydrogen to oxygen ratio setpoint, sending a signal to the oxygen flow control valve, thereby proportioning the oxygen flow control valve;

i. in the case wherein said oxygen flow control valve signal is below and not about 100%, sending a signal to said air flow control device closing said air flow control device.

ii. in the case wherein said oxygen flow control valve signal is greater than or about 100%, comparing said oxygen flow signal and said air flow signal to said hydrogen to oxygen ratio setpoint obtaining an air flow difference, sending a proportional signal to said air flow control device that is in proportion to said difference, thereby proportioning said air flow control device.

f. said control apparatus comparing said temperature signal to said warm temperature setpoint, said coolant temperature setpoint and said hot temperature setpoint:

i. in the case where said temperature signal is less than said warm temperature setpoint, less than said coolant temperature setpoint and less than said hot temperature setpoint, sending a signal to said combustion water flow control valve to close said combustion water flow control valve; and sending a signal to said coolant flow control valve to close said coolant flow control valve.

ii. in the case wherein said temperature signal is equal to or greater than said warm temperature setpoint, less than said coolant temperature setpoint and less than said hot temperature setpoint, obtain a difference between said temperature signal and said warm temperature setpoint, sending a signal in proportion to the difference between said temperature signal and said warm temperature setpoint, which obtains a hydrogen to combustion water ratio that is greater than said hydrogen to combustion water ratio setpoint, thereby sending a signal to said combustion water flow valve proportioning said combustion water flow control valve; and send a signal to said coolant flow control valve, thereby closing said coolant flow control valve.

iii. in the case wherein said temperature signal is greater than said warm temperature setpoint, equal to or greater than said coolant temperature setpoint and less than said hot temperature setpoint, obtain a difference between said temperature signal and said coolant temperature setpoint, thereby sending a signal to said combustion water flow control valve that obtains combustion water flow that is equal to the hydrogen to combustion water ratio setpoint; and sending a signal in proportion to the difference between said temperature signal and said coolant temperature setpoint to said coolant flow control valve, thereby proportioning said coolant flow control valve.

iv. in the case wherein said temperature signal is greater than said warm temperature setpoint, greater than said coolant temperature setpoint and equal to or greater than said hot temperature setpoint, sending a

signal in proportion to the difference between said temperature signal and said coolant temperature setpoint to said coolant flow control valve thereby proportioning said coolant flow control valve; sending a signal to said combustion water flow control valve closing said combustion water flow control valve; sending a signal to said hydrogen flow control valve, thereby closing said hydrogen flow control valve; sending a signal to said oxygen flow control valve, thereby closing said oxygen flow control valve; and sending a signal to said air flow control valve, thereby closing said air flow control valve.

305. The apparatus of claim 304, wherein mechanical rotating energy is created.

306. The apparatus of claim 305, wherein said rotating mechanical energy turns a generator to create electrical energy.

307. The apparatus of claim 304, wherein

the steam from said combustion turns a generator to create electrical energy.

308. The apparatus of claim 304, wherein heat is created.

309. (canceled)

310. The apparatus of claim 306 or 307, wherein electrical energy is created and at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen is at least a portion of said hydrogen source and said oxygen is at least a portion of said oxygen source.

311. The apparatus of claim 304, wherein nitrogen or argon is in the oxygen source.

312. The apparatus of claim 304, wherein at least a portion of the steam produced by combustion is converted to hydrogen by the corrosion of at least one metal.

313. The apparatus of claim 312, wherein said conversion of steam to said hydrogen is increased by an electrical current in said metal(s).

314. The apparatus of claim 312 or 313, wherein at least a portion of said hydrogen is at least a portion of said hydrogen source.

315. The apparatus of claim 304, wherein a generator turns due to the movement of air or water, and wherein

said generator creates electrical energy, and wherein

said electrical energy is at least partially utilized in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen is at least a portion of said hydrogen source and said oxygen is at least a portion of said oxygen source.

316. The apparatus of claim 304, wherein a photovoltaic cell creates electrical energy, and wherein

said electrical energy is at least partially used in the electrolysis of water to hydrogen and oxygen, and wherein

at least a portion of at least one of said hydrogen is at least a portion of said hydrogen source and said oxygen is at least a portion of said oxygen source.

317. The apparatus of claim 304, wherein said apparatus includes a cryogenic air separation unit, and wherein

said combustion powers at least a portion of said cryogenic air separation unit.

318. The apparatus of claim 317, wherein the nitrogen separated from air in said cryogenic air separation unit is used to cool any portion of at least one selected from a list consisting of: said cryogenic air separation unit, the storage of oxygen, the storage of hydrogen, electrolysis, coolant for said apparatus, said apparatus and any combination thereof.

319. The apparatus of claim 317, wherein the nitrogen separated from air in said cryogenic air separation unit is at least partially used to cool air or water.

320. The apparatus of claim 304, wherein said apparatus includes a membrane air separation unit, and wherein

said combustion powers at least a portion of said membrane air separation unit.

321. The apparatus of claim 304, wherein said apparatus includes a PSA air separation unit, and wherein

said combustion powers at least a portion of said PSA air separation unit.

322. The apparatus of claim 317, 320 or 321, wherein the oxygen separated from air is at least one of enriched oxygen, pure oxygen and very pure oxygen.

323. The apparatus of claim 317, 320 or 321, wherein at least a portion of the oxygen separated from air is at least a portion of said oxygen source.

324. The apparatus of claim 304, wherein at least one selected from a list consisting of a: corrosion inhibitor, chelant, dispersant and any combination therein is added to the water in said apparatus.

325. The apparatus of claim 304, wherein at least one of oxygen and hydrogen is stored in a cooled state or in a liquid state by liquefaction.

326. The apparatus of claim 325, wherein compressor(s) for at least one of cooling and liquefaction is powered by at least one of said combustion and a fuel cell.

327. The apparatus of claim 326, wherein said fuel cell is powered by hydrogen and at least one of oxygen and air.

328. The apparatus of claim 304, wherein at least one of said hydrogen and oxygen is stored in a mixture with frozen water crystals to form a gel.

329. The apparatus of claim 304, wherein at least one of said: hydrogen, oxygen and water is preheated prior to said combustion with the energy from at least one selected from a list consisting of: ambient temperature, said combustion, said combustion exhaust, an electrical radiant heat source and any combination therein.

330. The apparatus of claim 305, wherein said mechanical rotating energy from said combustion enters a transmission, wherein

said transmission engage in a manner that is inversely proportional to at least one of the torque and work output of said combustion, and wherein

said transmission output mechanical rotating energy turn a generator to create electrical energy.

331. The apparatus of claim 330, wherein said transmission engage a flywheel capable of storing rotational kinetic energy, wherein

said flywheel turns said generator.

332. The apparatus of claim 330, wherein at least a portion of said electrical energy is used in the electrolysis of water to hydrogen and oxygen.

**333.** The apparatus of claim 332, wherein at least a portion of at least one of said hydrogen is at least a portion of said hydrogen source and said oxygen is at least a portion of said oxygen source.

**334.** The apparatus of claim 304 or 307, wherein a pressure control device is in said combustion exhaust.

**335.** The apparatus of claim 304, wherein at least one of combustion heat energy and combustion exhaust energy is used to heat at least one of a gas and a liquid.

**336.** The apparatus of claim 335, wherein at least one of the gas is air and the liquid is water.

**337.** The apparatus of claim 336, wherein said exhaust energy discharge directly into said air or water.

**338.** The apparatus of claim 304, wherein there is not at least one of said source of coolant and said coolant flow control valve.

**339.** The apparatus of claim 304, wherein there is not at least one of: said source of oxygen, said oxygen flow measurement device and said oxygen flow control valve.

**340.** The apparatus of claim 304, wherein there is not at least one of: said source of combustion water, said combustion water flow measurement device and said combustion water flow control valve.

**341.** The apparatus of claim 304 or 317, wherein said apparatus is insulated.

**342.** The apparatus of claim 317, wherein hydrogen is separated.

**343.** The apparatus of claim 304, wherein said oxygen is at least one of: enriched oxygen, pure oxygen and very pure oxygen.

**344.** The system of claim 343, wherein there is no water addition to combustion.

**345.** The system of claim 304, wherein the temperature of said combustion is at least partially controlled with air to said combustion in excess over that required to perform said combustion, wherein said excess air performs at least one of reduceing: said combustion temperature and the formation of nitrogen oxide(s).

**346.** The apparatus of claim 304, wherein the temperature of said combustion exhaust is at least partially cooled with water.

**347.** The apparatus of claim 345, wherein there is no combustion water.

**348.** The apparatus of claim 345, 346 or 347, comprising jet propulsion.

**349.** The apparatus of claim 304, 343, 344, 345, 346 and 347, comprising rocket propulsion.

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